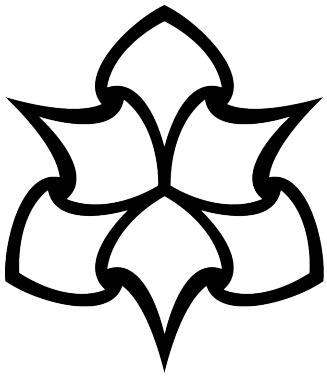

IASDR 2019

DESIGN REVOLUTIONS

IASDR 2019 CONFERENCE PROCEEDINGS | **VOLUME 2**

LIVING | MAKING | VALUE

EDITORS Professor Martyn Evans, Dr Annie Shaw, Dr Jea Hoo Na

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Manchester Metropolitan University

MANCHESTER SCHOOL OF ART

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About IASDR

The International Association of Societies of Design Research (IASDR) is an international, nongovernmental, non-profit-making, charitable organisation, and is comprised of member societies of design research from around the world. Established on 01 November 2005, its purpose is to promote research or study into or about the activity of design in all its many fields of application, through encouraging collaboration on an international level between independent societies of design research. IASDR members include the Chinese Institute of Design (CID), the Design Research Society (DRS), the Design Society (DS), the Japanese Society for the Science of Design (JSSD) and the Korean Society for Design Science (KSDS).

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Design Revolutions explored how design drives and responds to revolutionary thinking through questioning the norm, probing the now and embracing the new. For the first time IASDR conference was held in the UK and fostered new thinking towards a compelling, meaningful and radical dialogue regarding the role that design plays in addressing societal and organisational issues.

The biannual conference enables academics, practitioners and students join together to explore contemporary agendas, emerging directions and future challenges that are at the forefront of design research. IASDR 2019 will provide opportunities for the presentation and publication of a collection of high-quality peer reviewed research papers alongside the space to discuss and debate the evolution and revolution of design.

Editorial

In September 2019 Manchester School of Art at Manchester Metropolitan University was honoured to host the bi-annual conference of the International Association of Societies of Design Research (IASDR) under the unifying theme of DESIGN REVOLUTIONS. This was the first time the conference had been held in the UK. Through key research themes across nine conference tracks – Change, Learning, Living, Making, People, Technology, Thinking, Value and Voices – the conference opened up compelling, meaningful and radical dialogue of the role of design in addressing societal and organisational challenges. The conference was a truly international gathering of the key thinkers in design research from 28 countries. 215 papers were presented and 13 workshops delivered alongside two exhibitions. RADICAL RESPONSES was a peer-reviewed exhibition of the research-informed design practice from academic design staffs from Manchester School of Art. This was complemented by an engaging display of design artefacts from the MATERIAL AND PROCESS INNOVATION COLLECTION curated by University's Special Collections. Such diversity enriched the exchange of ideas at presentations, workshops and social events for the duration of the innovative and dynamic event.

Support and contributions from the design research community have made this conference possible. Our thanks go to each one of our 488 authors for the papers and workshops that provided a rich source of inspiration, all 162 reviewers for ensuring quality and rigour and the 44 session chairs for ensuring the effective flow of ideas and discussion throughout the sessions. We also extend our sincere gratitude to all delegates of the conference who questioned the norm, probed the now and embraced the new. We hope you enjoyed your experience of Manchester and look forward to welcoming you to our city once again.

IASDR 2019 was a part of the design revolution in progress. We are excited to see how these proceedings fuel on-going discourse and debate at IASDR 2021 and beyond.

Martyn Evans, Annie Shaw and Jea Hoo Na

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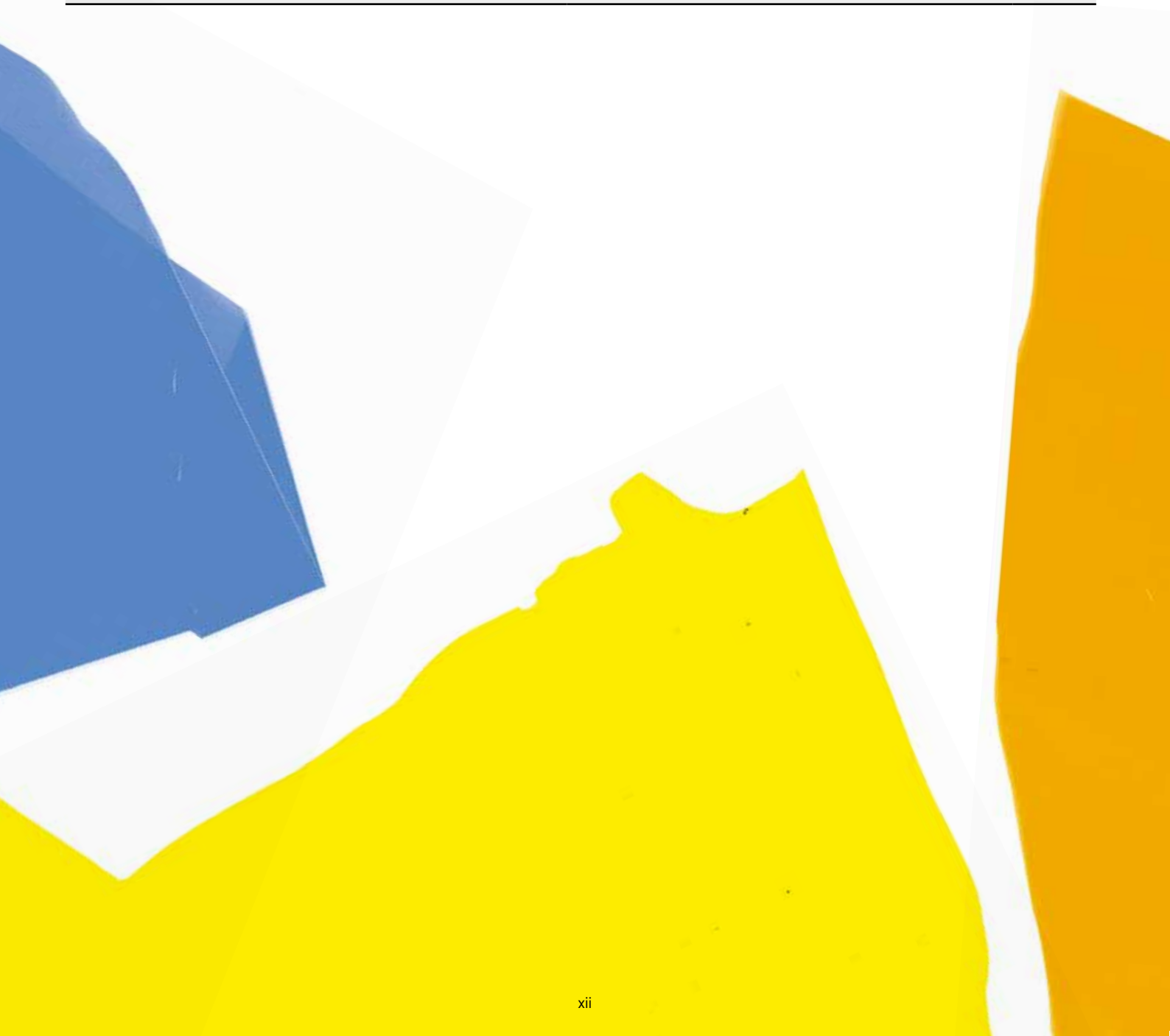

LIVING

DESIGN SURROUNDS US BY SHAPING THE WAY WE LIVE THROUGH OUR CONSUMPTION OF PRODUCTS, THE SERVICES WE USE AND THE CITIES WE INHABIT. IT IMPACTS THE ENVIRONMENT, HEALTH AND WELLBEING OF ALL. WHAT VISION OF LIVING SHOULD DESIGN SUGGEST? HOW SHOULD DESIGN BE USED TO ENHANCE OUR LIVES AND THE ENVIRONMENT? HOW SHOULD DESIGN IMPROVE THE WAY WE APPROACH SUSTAINABILITY AND THE CIRCULAR ECONOMY? HOW CAN DESIGN ENHANCE THE URBAN ENVIRONMENT?

A lifestyle with celebration from life to death – transformation of funeral parlour identity to go green and to act as a neighbourhood space

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Following the agenda of practicing green in funeral industry and educating the public to consider green funeral and green burial, more life and death education must be conducted. Funeral parlour can be served as the stepping stone to bring changes by providing alternative education to the public. To begin with, the educational purpose in funeral parlour must be addressed. With this in mind, design to break the threshold fear and to transform funeral parlour as a neighbourhood space is vital. The hypothesis of this paper is funeral parlour as a neighbourhood space to educate people about life and death issues and to go green. It is expressed through conceptual design by a group of interior architecture degree students in redefining funeral parlour to change the impression from inhumane and solely functional to a welcoming and green one.

Hong Kong as a densely populated urban environment, green funeral must be promoted but there are obstacles especially due to Chinese traditional belief. This paper is targeting on our next generation who will be the ones to witness these changes and to go green and to celebrate life. The scenario is more on Chinese circle and how to breakthrough from traditional practice and belief to go for a meaningful lifestyle with positive interpretation on death and eventually selecting green funeral and burial in order to benefit our nature.

Keywords: Funeral parlour design, green funeral and green burial, life and death education, neighbourhood space, celebration of life

1 Introduction

Green burial is one of the talks of the town. Go green in burial is not just in cities with limited space, big cities also acknowledge this issue. With relevant schemes to promote it. Hong Kong as a densely populated urban environment, the lack of land is always a big issue. Land allocated for burial is facing great challenges. Green burial is the ultimate solution but how to change the mindset and to promote effectively?

In traditional practice, people go to funeral parlour to attend memorial service before witnessing the burial ceremony. To educate people about green burial, funeral parlour is the first gate. By applying the theory of Celebration of Life, green funeral parlour should be

introduced to educate citizens that there is alternative. Break the threshold fear of funeral parlour is essential. Educate people to prepare ahead for a green ceremony to celebrate life. Promote a positive attitude, a paradigm shift from fear of death to celebration of life which leads to embracing death and talking about death.

It is believed that through design, nice and dignified outcomes can be produced to show respect to ancestors through green funeral and green burial instead of the traditionally oriented way with extravagant look as a gesture of showing respect and status.

When referring to Chinese context, respect is extremely important. Contemporary society needs innovative ideas to educate people about facing death positively. It is important to spread out new ideas and to change people's mindset, to educate them to breakthrough by stepping out of the comfort zone. It is especially relevant to target our next generation to start this green movement.

2 Literature Review

2.1 Definition of green burial and green funeral

Harris (2007) in the paper, A natural return: Going back to nature -- and tradition -- with green burial stated that "A "green burial" -- a simple return to the elements, in a natural setting, using nothing more than a minimal casket or cloth shroud was a fitting request for a self-described nature lover who tended a huge organic garden in his backyard." The term green burial is being practiced in Hong Kong by garden burial and sea burial. Below is a list of ways explained by Harris (2007) to go green including but not limited to the following common practices. The elaborations are focused in Hong Kong context.

Burial at sea -- scatter ashes to the ocean. In Hong Kong, Government provides ferry service to bring descendants to designated area to conduct this ceremony. However, the ferry is not a new one tailor-made for sea burial purpose, the design is very basic and functional, not reflecting suitable moods for the ceremonies. Because Sage La Green Funeral Services Ltd. is responsible for arranging this activity, they requested our design students to design for the table for ceremony, the print graphic onto the environmentally friendly bag to hold the ashes and other related items such as banners.

Simple coffins -- it can be coffin made by paper or a wooden coffin in pine. Apart from the standard ones, Sage La Green Funeral Services Ltd. also imported paper coffins with nicely printed graphic design.

Cremation – After cremation, ashes can go for garden burial or sea burial. Part of the ashes can also be used to made eternal gem. If not going for green, ashes placed inside container can be placed in columbaria either private or government ones.

Memorial reef – mixture of concrete and ashes to be placed in reef sites. It is not popular in Hong Kong but from green perspective, it is worthy to explore.

Home funeral – it is not popular in Hong Kong but when relating to the lack of space situation, it is worthy to explore.

Recently there are promotions of scattering ashes in the air, in the outer space or scattering ashes on ice.

Benjamin M. Stewart (2012) stated in the paper From committed to the earth: ecotheological dimensions of Christian burial practices that “In sum, the natural burial movement seeks (1) to care for bodies after death without toxic embalming, (2) to carry the remains of the deceased in burial vessels that are constructed with ecological considerations and that themselves biodegrade naturally, and (3) to commit bodies to the earth in ways that do no ecological harm, and perhaps, even in death, contribute to an ecological good.”

Secondly, Benjamin M. Stewart (2012) also explained that “natural burial practices can be powerful, meaningful, and even strikingly beautiful.” It is important to stay close to this idea to educate more people to go green. Especially vital to educate to our new generations. It can be powerful but it depends on a new mindset to interpret green funeral and green burial as a set of powerful practice. If people are searching for meaningful ways, green burial can be one of the expressions. If people need to beautifully present the green practice from funeral to burial, contribution from design is the key.

For the definition of green funeral, as refer to National Funeral Directors Association, the world’s leading and largest funeral service association, “a green funeral incorporates environmental-friendly options, and may include any or all of the following: no embalming or embalming with formaldehyde-free products, the use of sustainable biodegradable clothing, shroud or casket; using recycled paper products, servicing organic food; locally grown organic flowers; funeral guest carpooling; natural or green burial.” In Chinese practice, the burnt offering of paper products is not green too. Recently there is news that the paper products for burnt offering contain toxic. In order to explore green funeral, using artificial flowers to replace fresh flowers is also an appropriate direction to explore.

2.2 Chinese Attitude in Funeral

How can the message of green funeral and green burial be delivered to Chinese circle successfully? With Chinese love to go for elaborated ceremony by spending big money as a gesture of respect, green funeral must strive for green ideas but still can represent respect.

Apart from cultural issue, changing mindset of people looking at death is also vital. Life and death education are helpful to prepare the seeds for breakthrough. Issues such as how to prepare for ones own funeral, how to face death positively? How to release the taboo of fearing death? How to benefit the world with lesser consumption of our world resources?

Chen Zeng (2016) wrote in Ecological Citizenship and Green Burial in China to promote the idea of harmony with nature and admits that natural resources are limited. Human beings as the one who dominates the world eco system, one must control the desires for one’s selfish desires have already seriously damaged the world. Thus, ecological citizenship theory calls on human beings to reasonably control the desires, and to use technology to return humanity to a level of existence that establishes and maintains ecological balance. It inspires this research that Chinese following the traditional culture of showing respect as a reason not to go green is instead a selfish desire. Even people admit that it is important to show respect to the deceased but people needs to seek for alternative ways. It is unescapable that more dialogue must be generated to allow creative ideas for people to choose. Hence, promotion of a green lifestyle or a meaningful lifestyle can help. Government or related organisations must educate citizen what is green lifestyle and then how to go green even in death related events. It is mentioned that “this principle of reducing the ecological footprint of death is beginning to take root in contemporary China in the form of “green funerals and

graves", a concept that echoes the "green burials" currently in fashion in the English-speaking world." (Natacha, 2012). This is a good start in Chinese circle, Natacha even describes this movement as the "second funeral revolution". This is why green funeral and green burial must be promoted in a higher level. And with the contribution of design in green funeral and green burials, mindset of citizens, especially in Chinese cities, can be transformed.

In Chinese culture, Confucian ideas are talking about "loyalty to the throne" and "filial obedience"; Taoist ideas refer to "eternal existence" and "cultivation of immortality of the physical body"; and Buddhist ideas of "transmigration". The complicated variations vary enormously in detail throughout China, but certain conventional forms can be identified within all funeral ceremonies. In Chinese culture, filial or showing respect is important. That's why funeral service must be grand and spending money to buy expensive coffin, fresh flower stands and blankets. If Taoist funeral service has been selected, the cost will be higher for the ceremony includes a lot of burnt offering of paper structures. Generally speaking, spending more money is a mean of showing respect. In the book, Ecological Citizenship and Green Burial in China, Chen Zeng also explained that Chinese should respect for nature with the concept of "Tian Ren He Yi [天人合一]"—"Nature and human beings combine into an integral whole." (Chen, 2016). Chinese philosophy towards nature is talking about unity, hence, ecological direction in whatever dimensions to protect the nature is essential. In Hong Kong, with limited space, geographically speaking, go green in burial is a must. Together with education of Chinese philosophy to respect nature, go green in funeral and burial especially in Hong Kong is very substantial and convincing.

2.3 Hong Kong Perspective – Urban Context

Different writers expressed how difficult it is for Hong Kong to go green in funeral industry. (Blundy & Davia,2017; Javier, 2015; Zheng, 2018). One of the big hindrances is that traditional funeral parlours control majority of the business and they are aiming at gaining more money by promoting elaborated memorial services especially in ceremony under Taoism practice with burning paper offerings to ancestors. This type of funeral practice reflects the respect in Chinese traditions towards ancestors.

With limited space in a densely populated urban environment, funeral parlours are located a bit remote in an individual building. It is abided that Hong Kong is a vertical city with high rise and different types of businesses are located inside a block but never happens that funeral parlour is located inside a high rise building together with residential or commercial natures for it is still a taboo in Hong Kong. Majority of Hong Kong people associates dead body as something which will bring bad luck. Even there are private owned memorial centre or columbaria for display of urns with ashes which are located in high rise buildings, voices of rejection always exist.

2.4 Theory

Renowned scholar and priest, Henri Nouwen (1971) wrote in the book Creative Ministry about celebration of life. "Part of our celebration of life in the deep realization that life and death are not opponents but do, in fact, kiss each other at every moment of our existence." This theological standpoint relating to celebrate life when facing death and prepare ahead for funeral affirm transcendence of life from journey to grave.

Another sharing which indicate similar theory is elaborated in the chapter The Green Death, with topics about Embracing death, Talking about death, End-of-life issues which are stimulating for it can change the mindset towards death (Schroeder, Thompson, Firth & Pencheon, 2013). To generate more dialogue about facing death positively can help people to live a happier life. When one's mindset has the room for death and to go for pre-planning as mentioned, people are more cheerful in facing uncertainty. People will prepare ahead the memorial ceremony, what to reserve and apply. The target of going green is easier if green funeral and green burial are decided when someone is alive, then descendants would not be challenged if they want to select a green funeral and green burial method as an action of not showing respect. By opening more channels for dialogue about death, breaking death-denying taboo can be achieved in the near future. Apart from a positive direction to bring out a cheerful memorial ceremony, it is also mentioned that "Benefits apart from sustainability: cost, simple, cheerful, positive, more meaningful, lifestyle, personality …"(Schroeder, Thompson, Firth & Pencheon, 2013). In view of all these benefits, green funeral is better than traditional ones which require material display of extravagant elements.

2.5 Examples with design contribution to facilitate life and death education

In Korea, Hyowon Healing Center create meditative interior to experience staying in coffin, learn to love your life by dying with a mock-funeral-experience (Choe, 2016).

The Before I die wall as a global art project with nice simple design also facilitate people to contemplate death and have reflection about their lives. It helps people to treasure life and to live a meaningful life together with interpretation aiming at death positively.

3 Research Method

Qualitative research was applied in order to gather more in depth understanding of this issue. Through interview of experts, visit to traditional funeral parlours, visit to organisations related to life and death education, the scenario of funeral industry and life and death education were reviewed. Apart from applying the relatively more conventional research methods listed above, the researcher would like to see how younger generations interpretations towards green funeral and green burial. Hence, a group of design students are being assigned to design a new identity for funeral parlour with the assumption that breakthrough of funeral parlour is necessary in order to go green for next generation.

3.1 Interview

In the interview with Ms. Betsy Ma, founder of Sage La Green Funeral Services Ltd. and Sage Eternal Gem, who is an expert in funeral industry, she shared that traditional funeral parlours are difficult to go green because people in traditional funeral industry focus more on gaining money. A traditional ceremony includes many different items for customers to spend money such as the complicated ritual under Taoism and the burnt offering of paper products. She also mentioned that the atmosphere of traditional funeral parlours are scary. Hence a new funeral parlour should be warm and funeral service with more humane touch. The most important is to promote green. She wished that with design consideration, simpler way of ceremony can be presented decently. As a holistic package, green burial can be solemn and respectful with nice design too.

From another casual conversation and briefing by Betsy, she shared that it is possible to explore funeral ceremony in open space by using a big truck owned by her company. Therefore, the dead body can be placed inside the truck and people gather around the truck

to conduct memorial ceremony. It will then be cheaper and can also serve as a mean to promote green burial and green funeral. She reminded us that funeral service is not targeting on spending more money, but spending money wisely. Due to government regulation, only funeral parlours, some religious buildings such as churches and limited designated places are licensed to handle dead body in memorial ceremony but by the use of truck is an alternative.

In an interview with another expert, Mr Ng, who is one of the co-founders of White Lily Hong Kong which aims at holistic package in providing licensed funeral service. They provide personalized and high quality service so that a dignified and elegant farewell can be presented with love and care. The term celebration of life was introduced by him to express a positive way to look at death.

Another alternative is to conduct memorial ceremony without display of the dead body. From both Betsy and Mr Ng, more people are willing to arrange it this way and they both have experiences in this arrangement with very meaningful outcomes. They both also encourage us to explore how design can contribute to funeral industry for there is a lack of design concern. Ultimately, they hope that more attentions and discussions will be aroused for breaking through from traditional practices.

3.2 Field visit to Traditional Funeral Parlours

As a former pastor, visitation to different funeral parlours was a regular activity. The impression of funeral parlours was old fashioned, lack of design considerations with boring design. Overall comments was that the designs were functional with monotonous approach and ended up with a lack of human touch (see figure 1). It was interpreted that visitors were not focusing on the design but the ceremony. If in terms of design, the concern is a big hall with symmetrical design and high ceiling to deliver a grand atmosphere; use of expensive materials such as marble for the memorial hall; full of walls to display flower banquets and memorial blankets. All these elements are employed in order to bring a sense of respect and for customers who are willing to spend extravagantly in memorial service.

About the furniture, in order to fulfil the functional requirement, reception table and chairs are the stackable ones, reception table will be covered by cloth and chairs are sometimes covered by individual fabric jackets.

For example, in one of the visits recently, my relative had prepared a board to display photos in memorial of the ancestor. It was then located next to reception table by placing the board on an easel prepared by my relative. The aesthetic effect was not being well considered and there was no provision of facilities by funeral parlour.

Figure 1. Traditional Funeral Parlour in Hong Kong with monotonous approach in design

3.3 Visit to Taipei

To know more about how Chinese is promoting life and death education, a study trip to Taipei was being conducted to learn from them for they have different organizations targeting life and death education. We visited National Taipei University of Nursing and Health Science, College of Human Development and Health. They have a Life and Death Education and Counselling Graduate School. Apart from full time programmes to prepare graduate students to work in different professions related to life and death issues, they regularly provide short courses for general public to understand more about how to evaluate their health status in order to live well and how to prepare for a positive mindset to look at death. As stated in the website, “The college is dedicated to cultivating professionals in the holistic health development of people of all ages.”

It was also fascinating to visit Museum of World Religions. Apart from introduction of world religions, the most impressive is the Hall of Life’s Journey which showcases the roles of different religions from cradle to different stage of life until grave. As mentioned in the education session of the Museum of World Religion website, “life education has been promoted by different sections of society, including volunteers, teachers, staff, and others who worked on quietly.”

3.4 Student Projects - Views from Younger Generation

With the assumption or reality that green funeral and green burial will be flourished in our next generation, apply visual language to voice out ideas from young generations is phenomenal. It is assumed that through design, youngsters can be attracted to consider green. The aims of the student project is to promote and educate the publics green funeral and green burial as well as to deliver a message of celebration of life, plan ahead the end of life issue. To summarise from the 20 student works on green funeral parlour, breaking the threshold fear is significant. Identity or first impression has to be transformed.

Themes and uniqueness of different designs which are not directly related to funeral parlour in a traditional mindset: Café and neighbourhood space, Cheerful approach, Museum, Resort, Alternative way to show respect, Educational center, Integrate yoga area.

Style: they all applied contemporary touch with an application of natural elements to associate with green.

Mood: both cheerful and solemn moods are being executed.

Materials: mainly wood and green materials.

Lighting: bright with ambience lighting and spotlight.

To summarise primary researches conducted by students such as observation of existing funeral parlours and causal conversations with friends and family members, they realised that funeral parlours are very monotonous and the mood is gloomy and a bit scary. After research, the design directions from all students are targeting ways to attract more people to participate in different activities in the funeral parlour. By doing this, citizens will associate funeral parlours as a space which can be integrated with their daily life and arouse their curiosity to explore funeral parlours. When people breakthrough from this taboo and feel more positive in entering funeral parlours, education about green funeral and green burial will be more effective.

To conclude about funeral parlour design direction, the façade and entrance, as the first impression, it must be welcoming and green. About the memorial halls, there will be choices to fit with different rituals or mood by individual customers. The possible moods they have created are cheerful, relax, meditative, welcoming, natural and bright. Below are concepts, schematic diagrams and renderings of the 10 selected designs (see figure 2-11)

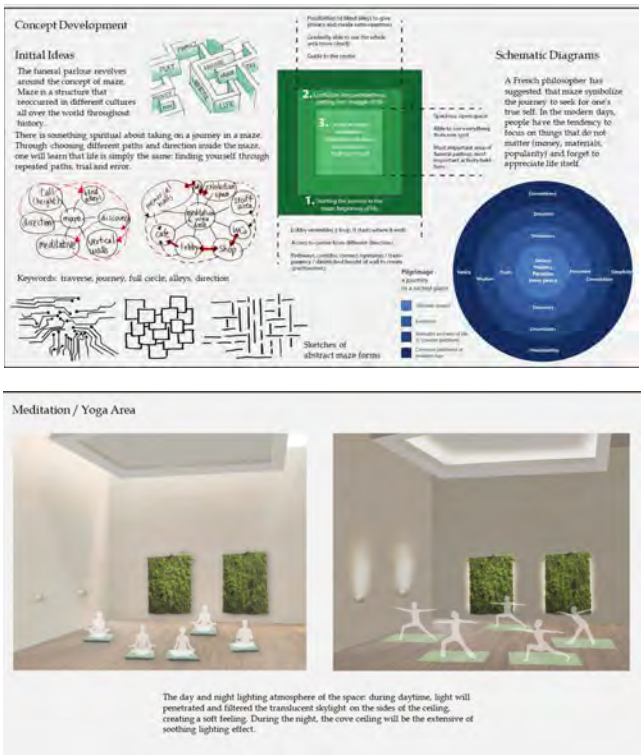

Figure 2. Maze as the theme with yoga activity inside

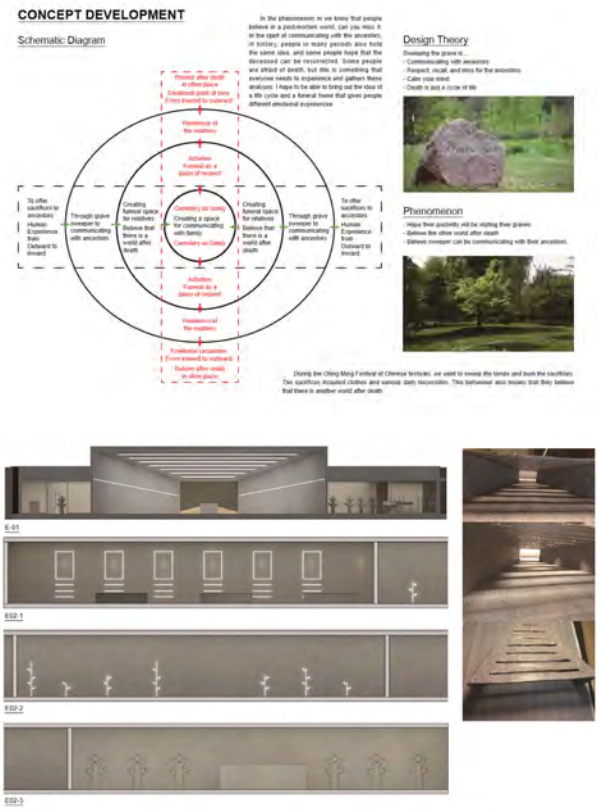

Figure 3. Creating a space for communication with family and providing different emotional experiences

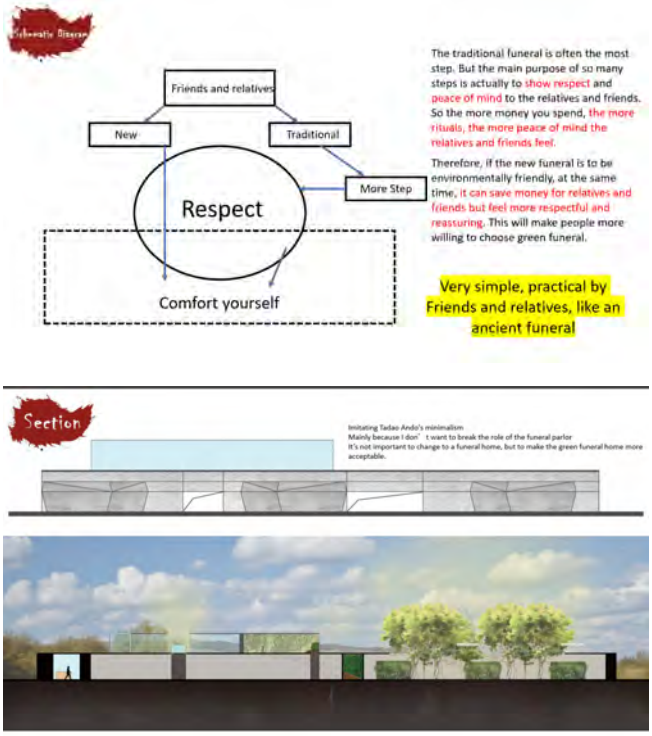

Figure 4. Alternative way to respect in a green setting

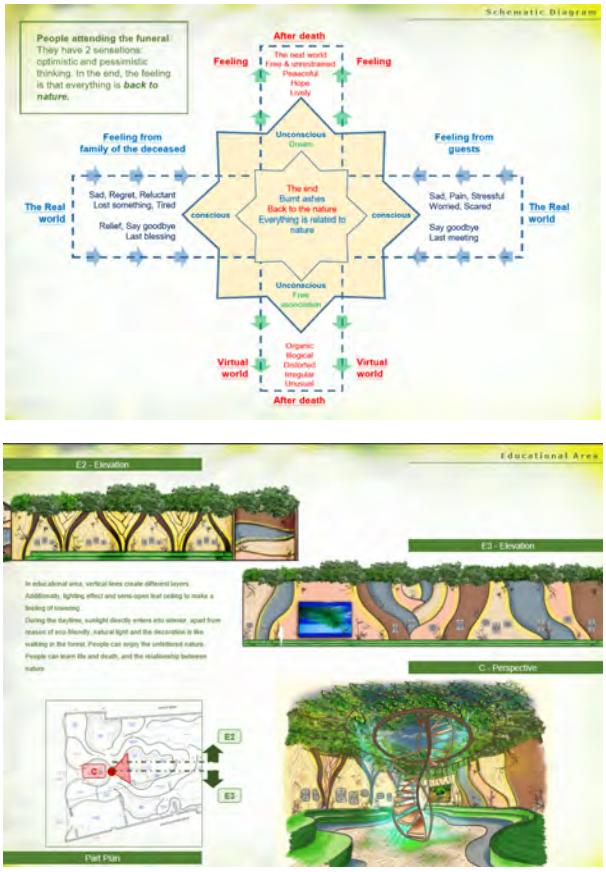

Figure 5. Cheerful approach and naturism

Figure 6. Resort – vacation related design – less stressful

Figure 7. Experiencing the path of finding different stations – exploring station, poer station and hope station

Figure 8. Educational Center to find meaning of life and understand green

Figure 9. Museum approach to learn from death and to make choices in life

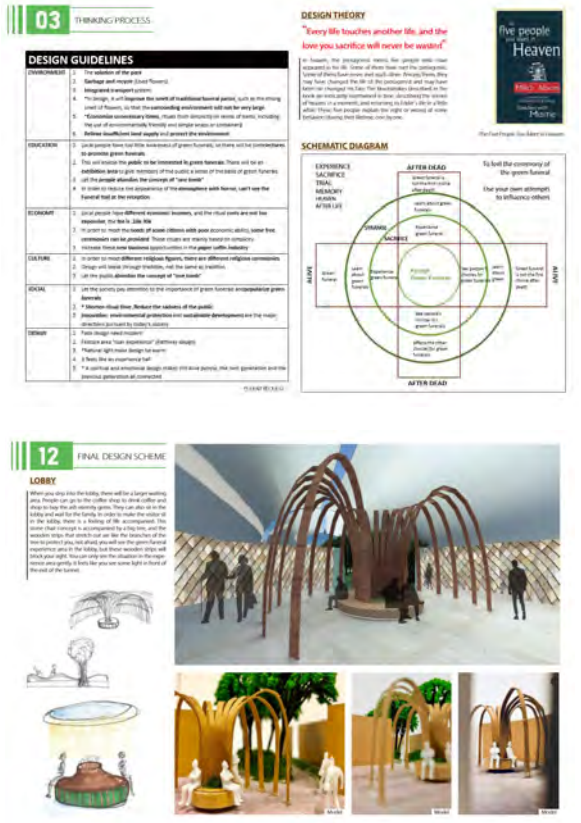

Figure 10. Experience imaginative ways in different burial methods through the tunnel concept to bring visitors to different experimental zones

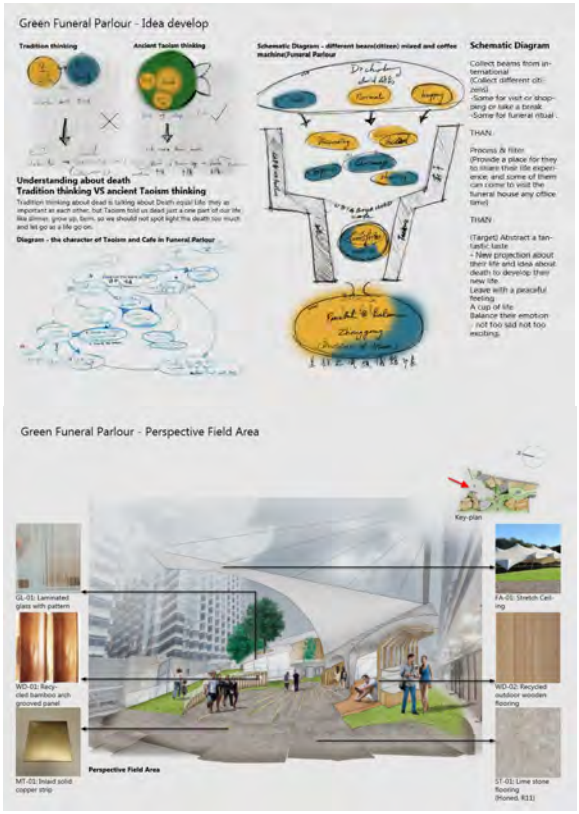

Figure 11. Café as the symbolic gathering space to build a sense of neighbourhood

4 Discussion

How can design contribute to green movement in funeral industry or life and death education? Based on the theory of celebration of life, can more ceremonies be conducted without dead body in order to go green so that more memorial halls without the licence concern in handling dead bodies will be launched to promote memorial services without dead body and ultimately green?

From Kelly Susanne (2015), “After all, humans are meaning-making beings. Suspended in what the anthropologist Clifford Geertz called ‘webs of significance’.” To apply this saying about humankind, the kind of meaning can be applied from life to death. The schematic diagram below can summarise how funeral parlour can be presented as a bridge between life and death (refer to figure 11).

When we promote green lifestyle, it is also promoting a meaningful lifestyle. This meaningful lifestyle will look at death positively with an attitude to celebrate life which is the theory behind this paper. With the concept of rest in peace, this is a sign to show dignity and respect. In order to reach a meaningful lifestyle, it is also meaningful to make decision to apply green burial.

Kelly Susanne (2015) also mentioned that “Rituals aren’t simply show and fancy, display and theater. Rituals fortify who we are, what we believe, and how we are to live.” Together with the student designs, ritual in funeral parlour can be meaningful, cheerful, celebrative and contemplative. All these atmospheres are appropriate with meaningful lifestyle to reflect the belief of people to go green and to respect nature. With this transformation, we must breakthrough the threshold fear of funeral parlour. It will be great to create funeral parlour as

a neighbourhood space, educational space and welcoming space for people to learn about life and death as well as green funeral and green burial.

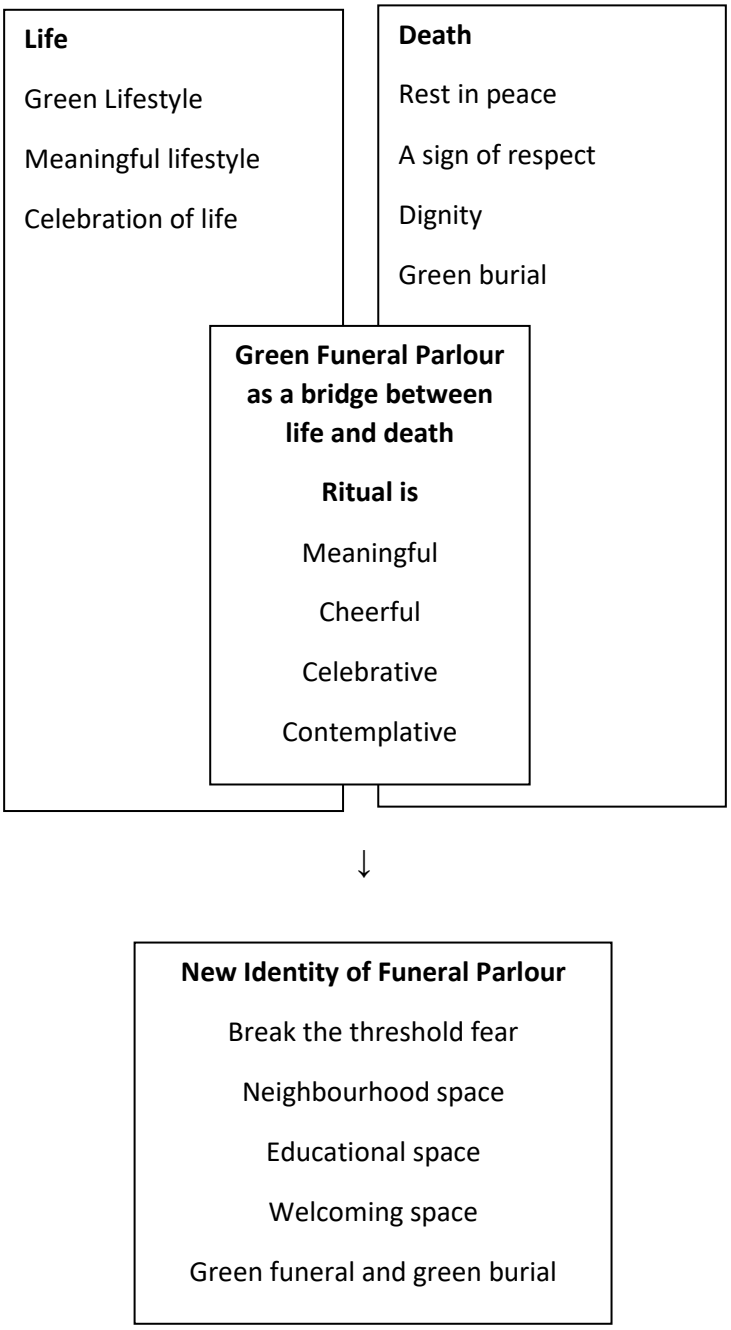

Figure 12. Schematic Diagram about Celebration of Life and Death through Rituals and Funeral Parlour

Traditional Chinese concept of funeral parlour is definitely serving the purpose of conducting memorial services. Therefore, people will not visit funeral parlours if they are not attending memorial services or dealing with funeral related matters. In Hong Kong, only funeral parlours and selected religious buildings are licensed to handle dead bodies, if we breakthrough the tradition of memorial service with dead bodies, new funeral parlours with green concept and new ideas can be launched with lesser restrictions. The taboo of handling dead bodies can be a hinder for neighbourhoods if we plan to locate funeral parlours next to busy residential area. If no handling of dead bodies, the hinder will be reduced. Moreover,

through outstanding design such as the designs by students as shown, visitors will be attracted, the scary association of funeral parlour can be eliminated too. Funeral parlour can be a welcoming space, inviting people to come and reflect about life and death, or to educate people about green funeral and green burial. Moreover, interior design can also be applied in the ferry for sea burial to provide a decent design to show higher respect to ancestors. Apart from interior design, graphic design in designing green burial utilities can enhance the quality of the ceremony too.

With the rise of more professional funeral services providers which provides holistic and alternative ways in funeral services such as Sage La Green Funeral Services Ltd. and White Lily Hong Kong, the preparation of memorial services when clients are alive is getting more popular. It is shared that more and more clients are willing to plan ahead and they even arrange memorial service called celebration of life when they are alive so that the ceremony is more celebrative and joyful.

The focus of these two companies is to provide holistic package with design consideration to stand out from the conventional funeral services providers who are focused on the traditional elaborated way to plan a funeral service. For example, White Lily Hong Kong focuses on using churches to conduct memorial services which can deliver a solemn environment to stand out from traditional funeral parlours. Sage La Green Funeral Services Ltd. also arrange memorial services without the dead body so that they can arrange it in a nicely designed room. One of the memorial services they have arranged was to create a joyful setting with wine and cocktail so that participants can memorise their love one with a celebrative mood requested by the deceased one when he was alive.

Together with other organisations such as Tung Wah Hospital Group which also promotes to their elderly members to plan ahead for their funerals, hoping that the green movement in funeral industry can be flourished soon. Therefore, our department also worked with them to design funeral clothes, memorial booklet and displays of their life journey in an exhibition (see figure 13). We even arranged a fashion show with the elderlies as models and with forum to further discuss about this topic.

Figure 13. One of the design package for elderly with personalised design such as funeral clothes, memorial booklet and displays of their life journey in an exhibition.

In order to bring a breakthrough, contribution from design industry can create attractive designs to the public to consider. Then, focuses can be placed on the environmental design to bring respect. Strategies by applying sophisticated design and design for funeral related items prior to death is significant. Therefore, whole package in sea burial and garden burial must be actualized too. Funeral parlours to go green and welcoming or even as a neighbourhood space is essential.

A book named Grave Matters by Mark Harris (2007) discussed about the significance of tomb to educate people great contributions of celebrities. This kind of symbolic meaning is also meaningful for consideration but it is not green. The dilemma is that whether people who contributed greatly has the right not to go green after death. Again, can design industry provides alternatives to strike for a balance? The idea of green funeral is a great step forward to bring life and death issue closer to everyday life. Following this conviction, a lot of discussions must be generated in the near future especially for the benefits of next generation.

5 Conclusion

With the agenda to promote green in funeral industry and to educate the public to consider green funeral and green burial, more life and death education must be conducted. Funeral parlour can be served as the stepping stone to bring changes. At this stage, promotion of funeral parlour without handling of dead bodies can be executed. By then, the educational purpose in funeral parlour must be addressed. With this in mind, design to break the threshold fear and to create funeral parlour as a neighborhood space is relevant and beneficial. No matter people who go with a purpose can learn from their visit, neighbours can go to relax and chill but ended up learn something in a more casual manner.
The hypothesis of funeral parlour as a neighbourhood space to educate people is consolidated and developed by the interior architecture degree students who were studying final year in interior architecture and participated in the project to design funeral parlour. They presented their views, concepts and designs to voice out their expectations. Moreover, the Schematic diagrams generated by them with theories or philosophies to support and justify the message are interesting and covering both Chinese and Western mentality.
From literature review, respect to ancestors are important but Chinese also respect nature. Hence, green burial and green funeral are the right track in order to reduce the land occupancy and the carbon footprint as well.
This paper can serve to stimulate more dialogue with solid ideas to transform the identity of funeral parlour. We may not be able to witness a dramatic change but next generation will be the ones.

With reference to the scenarios in Taipei which is one of the influential cities in Chinese community, it is expected that more breakthrough will be happened in the near future. By planning to arrange exhibition and forum to showcase the creative results of the students' projects together with report from media, hoping that Hong Kong government will do more actions to transform funeral industry. This green movement in funeral industry will be gradually flourished around the world.

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Beyond ‘consumer – user’: living as stewards in a circular future

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This is a conceptual paper exploring the role of designers in moving the public from passive consumers and engaged users to active stewards of resources for future generations. The paper makes the case that the skills needed for a circular future are those used by communities of practice in the sharing economy. Results from a recent action research project undertaken by the author will be used as background for the discussion. The research explored the issues faced by library staff when planning and delivering new digital skills workshops to the public. The research team took a three-phase approach: engaging with the staff in a focus group exploring the barriers to digital skills delivery; actively observing staff during digital skills workshops with the public; and running group evaluation sessions to explore successes and failures experienced. Journals provided the researchers with insights into how some of the staff had developed their own personal learning outside the research project. The methods used produced qualitative data insights into the issues in this area and gave the participants space to develop their own solutions. This paper concludes by reiterating the importance of the role of designers in helping the public to embrace the circular economy through stewardship. The project discussed is used to frame further areas of research into the importance of communities of practice on future resource stewardship.

Keywords: circular economy; stewardship; sharing economy; communities of practice; action research

1 Introduction

The world is moving towards the point of no return. Carbon emissions need to be dramatically reduced by 2030 to prevent catastrophic climate change (Norton, 2018). Now is the time for radical action. The circular economy is poised to revolutionise how businesses operate and the way that the public consume (Ellen MacArthur Foundation, 2013a; Ghisellini, Cialani, & Ulgiati, 2016). For the circular economy to be adopted as quickly as it needs to be, designers must be at the forefront of the movement. The task is twofold: to ensure that all new materials, products and services fit the new economy; and to guide and facilitate the change in public attitude. The design of products and materials must look past the consumer/user dichotomy and advance to one of stewardship, where the value of an item is not just on how it looks and functions at the time of purchase but on its longevity, the sustainability of the materials used, and how easily it can be maintained, adapted and valued by future generations. This shift will require radical new ways of thinking and doing. Designers have the knowledge and skills to make these radical changes seamless.

This paper addresses the *Living* track of the IASDR conference. It makes the case for designers to move the public from passive consumers, to engaged users, to ultimately active stewards. It explores ideas of stewardship through a key aspect of the circular economy, the sharing economy (Cooper & Timmer, 2015; Hobson & Lynch, 2016), and the creation of communities of practice (Wenger, 1998b) to share ideas and best practice. The paper uses the Ellen MacArthur Foundation definition of circular economy, a model "*that decouples revenues from material input*" (Ellen MacArthur Foundation, 2013a, p. 7). This definition is currently the most widely used across business and academics (Gallaud & Laperche, 2016; Hobson & Lynch, 2016; Yang, 2016).

Research is presented that uses a mixed methods action research design to explore the creation of a community of practice in libraries across a region of North West England. The project focuses on the delivery of digital skills to the public, using participants from twelve libraries in towns and semi-rural locations. Using the data from this research the paper concludes by arguing that libraries are an essential location for the dissemination of stewardship skills. This paper's key contribution to the field of design is arguing for active stewardship on the part of everyone in a circular economy, with libraries at the forefront of the dissemination of these skills.

2 Design and the circular economy

Design has a huge role to play in the circular economy, from product designers ensuring that design for disassembly and reuse is built into every new product; to town planners re-thinking urban areas to make them easier to move around without the need for individual fossil fuel driven cars. As Enzio Manzini argues "*we are all designers"* (2015, p. 1) not just as individuals but groups, businesses and organisations too. People led design is at the forefront of moving to a circular economy; collaborations are needed between expert designers and other fields to come up with the materials, products, and habitats of the future. Design thinking is needed to help with *"sense making"* in the new circular world.

Much of the work on design and the circular economy is currently focused on production (Blomsma & Brennan, 2017; Ellen MacArthur Foundation, 2013b; Ellen MacArthur Foundation & IDEO, 2017; Lofthouse & Prendeville, 2018; McDonough & Braungart, 2009; Yang, 2016). Design can add so much more to the circular future. The move to circular systems needs transformation, not only at the level of production but of how we consume (De Los Rios & Charnley, 2017). As society becomes more conscious of the impact of late capitalist levels of consumption, we are moving from being passive consumers to engaged users. The more engaged we become with the fight for the environment, the closer we will move to becoming active stewards of products and materials for future generations. Designers are the experts to ease society through this transition.

3 From consumer to user

Design is not just restricted to the products we use but covers every aspect of life: from the services we use, the layouts of our cities, our travel and communication networks. Designers have been at the forefront of the move from passive consumer to engaged user, providing the tools for co-creation, open design and transparent feedback in the design of products and services (Cruickshank, 2014; Rossetti di Valdalbero & Birnbaum, 2017). The skills and methods used to change passive consumers into engaged users must now be deployed to

facilitate the move towards active stewardship, ensuring the purchaser is demanding longevity of materials in all relevant products. This will help to accelerate the circular economy at every level.

Currently, there is a business lead in the move to the circular economy, but for it to be comprehensively adopted there needs to be a radical shift on the part of the purchaser. Designers are in an important position to help with adoption of the circular economy by the public, which could be the most difficult part of the new model to instigate. Research done by Kirchherr et al (2018) shows that *'lacking consumer interest and awareness'* is the most pressing issue preventing wide-scale adoption of circular economy (2018, p. 268). Persuading the public to change their habits and become stewards instead of consumers is where designers should be focusing their efforts. To embrace stewardship, we must reject the culture of constant consumption. Habits need to change to avoid buying new products: either by fixing what we already have, reusing a more durable item, buying second-hand, or borrowing. At the point of purchase this could be achieved by expressing the true value of a product or material and the full cost of that resource to the environment should be made clear. Arming the purchaser with knowledge will encourage the move from use to stewardship.

4 From user to steward

Previously environmental stewardship has focused on urban design (Felson, Bradford, & Terway, 2013), corporate social responsibility (Cai, Cui, & Jo, 2016; Kirchherr et al., 2018), or the responsibility of environmentalists in the natural environment (Milton, 1996). Within the circular economy stewardship is centred on manufacturers (Hill, 2014; Jensen & Remmen, 2017; Korpalski, 2002), with little focus on the role of the purchaser (Singh & Giacosa, 2019). It is not enough to be an engaged user of a product in a circular world, purchasing a product must come with the responsibility to be an active carer of that product, maintaining it and valuing the resources that go into making it. The move to stewardship demands a reconsideration of our relationships and interactions with everyday objects. Designers must facilitate the public to becoming active stewards, conscious of the products they buy, and the materials used to make those products. The idea of stewardship should extend to every aspect of life.

Perhaps the warm values of craft and creativity can help here, offering a positive vision of making and reusing, rather than the more austere and negative-sounding 'stop that!' message suggested by anti-consumerism arguments and shocking pollution news.

(Gauntlett, 2011, p. 58)

Repair and maintenance should become a normalised part of the transition to a circular economy. Care and responsibility for products should be a part of ownership, not just for use now but for future generations. The skills and knowledge needed to ensure this longevity can be developed through communities of practice where people come together to learn and share (Lave & Wenger, 1991). These ideas will be explored in more detail below.

The life of a material should be widely considered in the design of that product; some petroleum-based materials in use today will not degrade for many hundreds of years. It is the role of designers to create products and systems that see these products in use for

generations to come. The responsibility of ensuring the stewardship of these materials and systems fall to everyone.

5 Skills for stewardship

Within the circular economy and design literature there is a primary focus on products yet to be made, but a lack of discussion around the maintenance of products that are already in circulation (Lofthouse & Prendeville, 2018). There is a need for close collaboration between designers and makers of different disciplines to develop strategies for current and future stewardship. It is important that knowledge is shared at every level (De los Rios & Charnley, 2018). Skills for stewardship can be developed through maintenance of products already in circulation. Promotion of stewardship and transparency of the true value of a material could help to change public attitudes towards repair and maintenance (De Los Rios & Charnley, 2017; Singh & Giacosa, 2019). The skills needed can be shared through informal communities of practice which exist in physical and virtual spaces, where skills, tools and knowledge can be developed and shared (Gauntlett, 2011). Repair cafes and tool libraries are global examples of where communities of practice have made an effort to keep products out of landfill and reduce consumption. Repair cafés are "*community-supported events designed to help local residents fix and learn to fix their broken consumer products*" (Rosner, 2013, pp. 51–53). Makerspaces such as FabLabs are more permanent spaces often used by professionals and run collectively (Bjørner, 2013; Prendeville, Hartung, Brass, Purvis, & Hall, 2017). However, as Fleischmann, Hielscher and Merritt (2016) lament, their potential as spaces for sustainability are not often realised, "*if existing transformative social and environmental claims about labs should become a reality, there might be a need to debate more actively the role of digital fabrication technologies in wider change processes.*" (2016, p. 126). These spaces will be essential in the move to stewardship, so it is imperative that designers work with these spaces to realise their full potential. In spite of the number of local programmes to keep waste out of landfill, wholescale adoption of these initiatives by the public will need policy intervention as well as a concerted effort to push for better awareness (Prendeville et al., 2017).

6 Sharing economy and communities of practice

These spaces and the ethos they promote are a part of the *sharing economy*. The sharing economy is argued to be a key component of the circular economy (Burger, Stavropoulos, Ramkumar, Dufourmont, & van Oort, 2018). Economist and author of *Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist* (2014), Kate Raworth, describes the sharing economy as one "*in which the culture of ownership […] is giving way to a culture of access"* (2014, p.264). This access is increasingly provided through online platforms where tangible items can be rented, swapped or sold second-hand, and intangibles such as entertainment, music, software, and education can be shared for little or no cost to the user (Geissinger, Laurell, & Sandström, 2018). The sharing economy will be an essential part of future stewardship as the public learn to care for items they own and their natural environment.

Skill sharing and education through online platforms such as YouTube or in offline spaces such as repair cafés demonstrate places where communities of practice can be formed. Informal communities of practice in the sharing economy will be an essential part of

stewardship. Etienne Wenger (1998) developed the theory of 'communities of practice'; based on developing a shared expertise:

they are not defined by place or by personal characteristics, but by people's potential to learn together. Unlike the trajectory of a team planned from the start, communities unfold over time without a predefined ending point. Communities often start tentatively, with only an initial sense of why they should come together and with modest technology resources. Then they continuously reinvent themselves. Their understanding of their domain expands. New members join, others leave. Their practice evolves.

(1998a, p. 11)

Communities of practice are very much rooted in the domain of shared experience and expertise and should be an essential component of the move to a circular economy. The structure of a community of practice can be seen in Figure 1, where members become more or less involved over time. Through the establishment of informal communities of practice, designers can facilitate a move towards stewardship through the sharing of best practice and openness. At the first Festival of Maintenance (2018) held in London, Chris Hellawell, from the Edinburgh Tool Library, spoke about the community of practice that has developed organically through lending and sharing of skills and tools (James, 2018). David Gauntlett, in *Making is Connecting* (2011), expands on the ideas of the sharing economy and communities of practice; discussing how creativity and DIY, or fixing, culture are bringing people together, improving communities, and increasing engagement in local issues. He links creativity, sharing and making to circular economy ideas by looking at the Transition Towns movement; one that focuses on town level actions aiming to reduce fossil fuel reliance and improve residents' resilience (Transition Network, 2016).

The Transition movement stems from the idea that human beings are creative and can work well together to do great things. […] This helps us to build resilience and the creative capacity to deal with significant changes.

(Gauntlett, 2011, p. 20)

Resilience through creativity and building local connections will be an essential part of the move to circularity. As growth is decoupled from resource productivity the public will need support in moving to the circular future. The rest of this paper will examine how communities of practice can be established to provide skills and education to the public, using the example of a project conducted by the author.

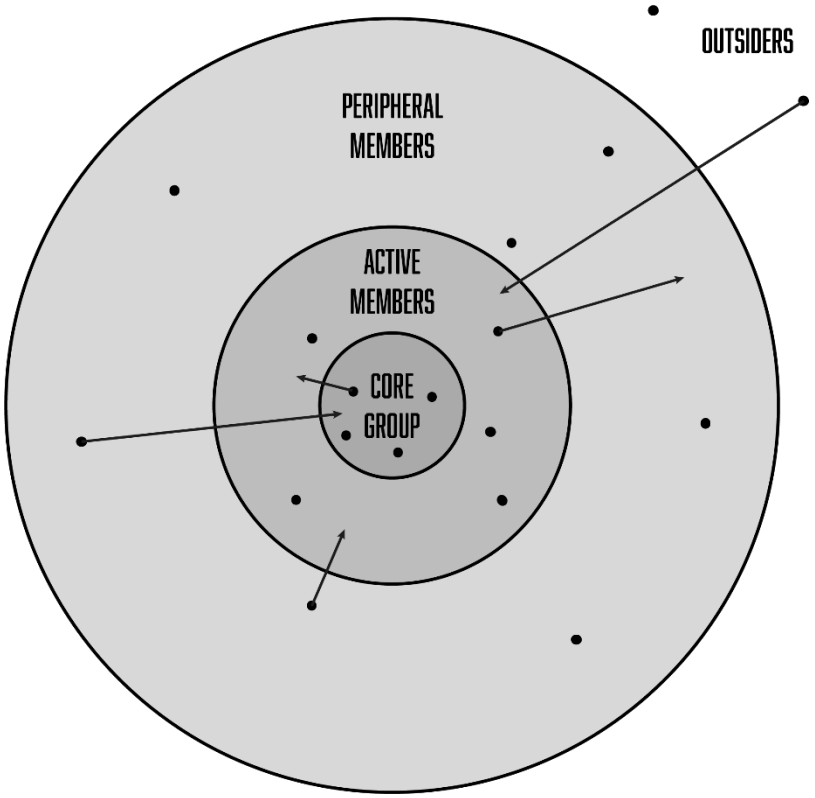

Figure 1. Degrees of community participation and movement of participants. Adapted from Wenger, McDermontt and Snyder (2002)

7 Libraries as a place for stewardship

The discussion around repair cafes and makerspaces in this paper has so far not looked at the issue of locations for these events to be held in. The research has shown that cities can provide a number of places of stewardship (Bjørner, 2013; Prendeville et al., 2017). However, many smaller, more rural locations do not have the capacity for such places. Outside cities, libraries provide the ideal locations for the creation of communities of practice, where engaged users can become active stewards. Traditionally, libraries have always been places of stewardship, where knowledge is shared and maintained for generations. Designers can learn from librarians and develop models of what life can look like in a circular future when stewardship, protection and maintenance of resources are key tenets of our lives. Libraries are not just passive places of learning; their role is changing. Once quiet libraries are becoming active spaces for collaborative learning and sharing. The role of the librarian is changing too; they are being encouraged to expand their skills to include new forms of learning such as digital literacy and creative media technology exploration (Arts Council England, n.d.). Using these familiar, traditional, public locations designers can engage with librarians to create communities of practice around new skill development, while instigating new forms of stewardship. Libraries are the ideal place to train the public to become stewards of a sustainable, circular future.

The move to stewardship of materials is currently being facilitated by the new technologies of Big Data, IoT and AI. These technologies promise a radical shake up of work and consumption, requiring new skills to navigate the future jobs market and new attitudes to products. A 2017 NESTA report argues that that:

our future economy will be built on creativity and technology. […] UK labour market projections show that the rate of growth for both creative and STEM (science, technology, engineering and mathematics) occupations will be more than double the average job growth across the whole UK economy.

(Bakhshi & Yang, 2017, p. 1)

Digital skills will be at the forefront of this change and the dissemination of these skills to different generations is crucial for a thriving economy. Using the libraries as a place to develop these skills can provide access across age ranges (Bertot, 2016; Blikstein, 2013; Bossaller, 2017). In the move towards a circular economy it will be essential that as many people are skilled for the future as possible. New business models based on these technologies are helping to accelerate the move to the circular economy. Manufacturers who embrace future tech are able to maintain control of their materials and track them through the product life-cycle (Bressanelli, Adrodegari, Perona, & Saccani, 2018; Kirchherr, Reike, & Hekkert, 2017; Pagoropoulos, Pigosso, & Mcaloone, 2017). To ensure the retention of the material, the user must become a key stakeholder, sharing usage and maintenance data with the manufacturer. The more that users are made aware of the technologies collecting data and understand how that data is being used, the more conscious they will become in the use of those products, encouraging the idea of stewardship.

As libraries undergo transformation to broaden their offerings, designers can make use of this by collaborating with librarians to bring ideas of stewardship to the public. Libraries have a key role to play in demystifying the technologies that will be embraced by future circular manufacturers. Libraries are a safe comfortable environment for the public to be exposed to these new technologies (Zach, 2011). Using libraries as locations to run digital skills workshops is a positive step towards demystifying these technologies, not only for the public taking part, but also for the staff delivering them.

8 “Common Knowledge”

The Arts Council has been the development agency for libraries in England since 2010, and the promotion of digital skills is a key part of its agenda. Its work in the libraries has focused on four priority areas: (1) promoting libraries as a community hub, (2) making the most of creative media and digital technology, (3) ensuring libraries are resilient and sustainable, and (4) delivering the right skills for those who work in the libraries (Arts Council England, n.d.). These priorities can be addressed through the establishment of libraries as centres for circular stewardship. An action research project, “Common Knowledge”, was developed by Transformation North West researchers in collaboration with twelve libraries in a region of North West England to respond to these priority areas. The project aimed to increase digital project delivery within libraries while encouraging an embracing of the unfamiliar by staff. An approach was developed that used Mixed Methods Research within an Action Research framework. The researchers used a mix of facilitated workshops and observation to understand how the staff felt towards the digital skills they were expected to deliver. Surveys and journals were used to track the changing attitudes of staff and explore whether a community of practice had been established through the development of connections with other participants. The data from these sessions was used to create appropriate interventions in the delivery programme. As previously argued, encouraging an exploration

of the unfamiliar and demonstrating new ways to interact with technology is an important step towards passive consumers becoming engaged users and ultimately active stewards.

The project developed in response to library management identifying a unwillingness among library staff to ‘step outside of their comfort zone’. Staff were reluctant to deliver public workshops in subjects where they lacked confidence, such as digital creativity or coding, due to a perceived lack of experience in those subjects. These observations are reflected in Arts Council England's report *Envisioning Libraries of the Future: Phase 1 & 2: "staff in many places lack some of the most important skills needed for the future – be it […] using digital technology, […] or leadership in a fluid environment."* (2013, p. 3). As part of their Arts Council remit a programme of creative digital engagement sessions had been run, bringing in outside experts to deliver workshops to the public. The funding for this programme was coming to an end so the management and council were keen to pass the delivery of workshops on to staff. Training was provided in two ways: either in depth training early in the year but without the opportunity to deliver to the public until a later date, or a brief training session followed by a supported workshop with the public. Despite positive uptake for both styles of training sessions, both sets of library staff were reluctant to develop programmes of their own without an outside facilitator. They reported not feeling they had the skills or confidence to deliver digital skills workshops to the public. The management team invited the researchers to develop a project that could explore the barriers the staff felt towards the delivery of the programme and and identify where interventions could be made to provide better support. Through facilitated sessions the research team and management hoped to find easily implementable solutions to the barriers faced. Due to funding restrictions faced by the libraries the research team agreed that the implementation of a community of practice would help to strengthen the self-directed learning of individual librarians, providing them with a platform to share ideas and experiments. The establishment of a community of practice would be assessed by establishing whether new ties had been created by library staff members, using social network analysis gathered through surveys and qualitative data from journals.

8.1 Delivery

The project was delivered through facilitated group sessions. The introductory sessions were run twice, once in the south of the region and another in the north. The researchers used visual tools to initiate discussions around barriers to digital skills delivery with participants, and to provide baseline data for further sessions. Exploring how pervasive digital skills are within the library, participants were asked to list all the activities run at their libraries and those with a digital element were then identified. This demonstrated the prevalent nature of digital and opened up the discussion around how much it is already integrated into library service delivery. This exercise led on to a word association task that explored different definitions of digital; exposing reasons for developing participants' skills and highlighting barriers to the uptake of these skills. Key words from this exercise were then used to develop a Socratic Wheel which determined how confident the participants felt about these areas. The Socratic Wheel is a “*deceptively simple and powerfully visual tool”* (Chevalier & Buckles, 2013, p. 120) that allows for the establishment of baseline criteria which can be used to evaluate, assess and compare participant profiles throughout a project.

At the start of the session the participants were asked to complete a survey to determine the level of connection between themselves and their colleagues also taking part in the project. It also asked participants to assess the level of community within the library service as a

whole. The researchers found that inter-library community was almost non-existent, but within the libraries there was a strong feeling of community. In order to provide another layer of analysis of new connections created between participants and self-directed study, participants were asked to keep a journal throughout the duration of the project.

Due to the geography of the region, shift patterns and poor public transport it was important to provide two introductory sessions to ensure that there was a representation from libraries across the area. The first session took place in the south of the region where the council and library management are based. This group consisted of a lot of senior and management level staff and the researchers found that the attitude towards the digital skills agenda was positive. The fact that some of the senior staff who had initiated the programme were participants may have influenced some of the discussions, but the surveys allowed for the opportunity to discuss feelings more candidly. The second sessions in the north of the region consisted mostly of librarians and assistant librarians. The participants in this group expressed a lot more caution towards the digital skills programme and there was a feeling that the north libraries were neglected in terms of finances and resource support in comparison to the south. The word association task led to a lot more negative words about digital than the first group. However, participants were pleased to be given the opportunity to meet each other, find common issues and work through them together.

Following the group sessions, refresher workshops were provided for staff who needed them, followed by supported workshop delivery with the public. The researchers observed the delivery of these sessions in different libraries over the summer delivery programme. Evaluation sessions were conducted where successes and failures were discussed, and the survey was repeated. The results of this survey fed into the social network analysis, which will be discussed below.

8.2 Social network analysis

At the start of each group session a survey was conducted with participants to determine the strength of professional connections between each of the participants, and whether the participants felt a sense of community within the libraries. The aim of questioning the strength of connections between the participants at the beginning and end of the project was to provide data so the researchers could identify whether any of the relationships changed over the course of the project, which would signify the strengthening of a community of practice (Kezar & Gehrke, 2017; Wenger, 1998a).

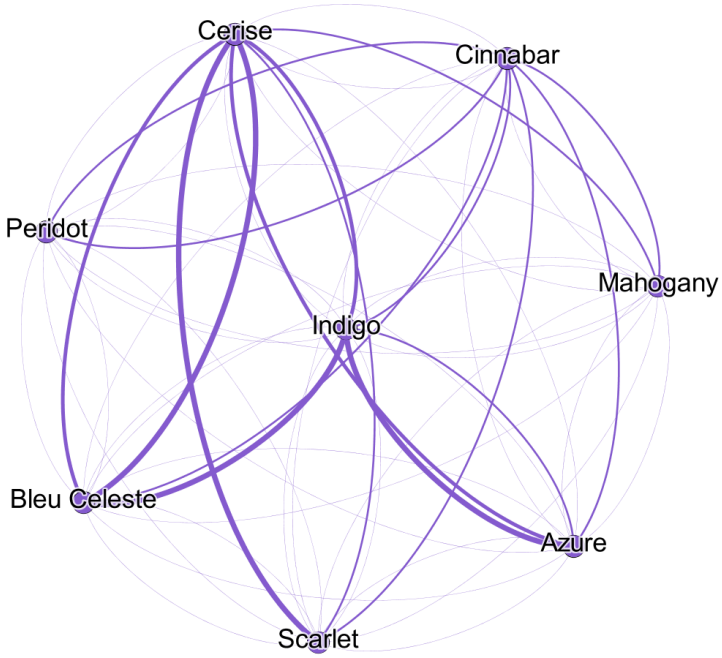

Figure 2. Connection changes between Group 2 participants. Thicker lines indicate a strengthening of the ties between participants.

Of the two groups that took part there was a completion rate of about 50%. From the first group four of the ten participants took part in the evaluation and eight of twelve from the second group. The participants who took part in the evaluation session were asked to repeat the connections survey, so the researchers could determine whether any ties had developed or strengthened during the project. The data revealed that there were a few members of staff who had developed new ties with colleagues from outside of their libraries through working together, participating in training workshops and email communication (see Figure 2). Journals submitted by participants detailed some of the establishment of new ties.

A core group of interested staff developed over the course of the project. These participants had gone beyond the original scope of the project establishing an informal community of practice, sharing knowledge and skills with one another, and complementing the work they were doing with external research. The management were aware of some of these participants, and were keen to provide support to the group. The journals helped to identify quieter, less obvious participants who were also acting beyond the remit of the project.

8.3 Project evaluation

The discussions in the evaluation sessions focused on how useful the librarians had found being able to meet colleagues from other libraries and share best working practice. "[I]*t was great to explore what 'digital' and technology means to different people. I will take away the expression "we are all learning together" – to use when up against people who are resistant to technology*" (taken from a participant journal). The researchers witnessed a lot of cross-library collaboration that they were told had not taken place much before. The journals also revealed that some of the participants are now learning digital skills such as coding as part of self-directed study. One participant applied to do an MSc in Digital Media Design off the back of the project, planning to take back the skills learned through this course to their role as a librarian.

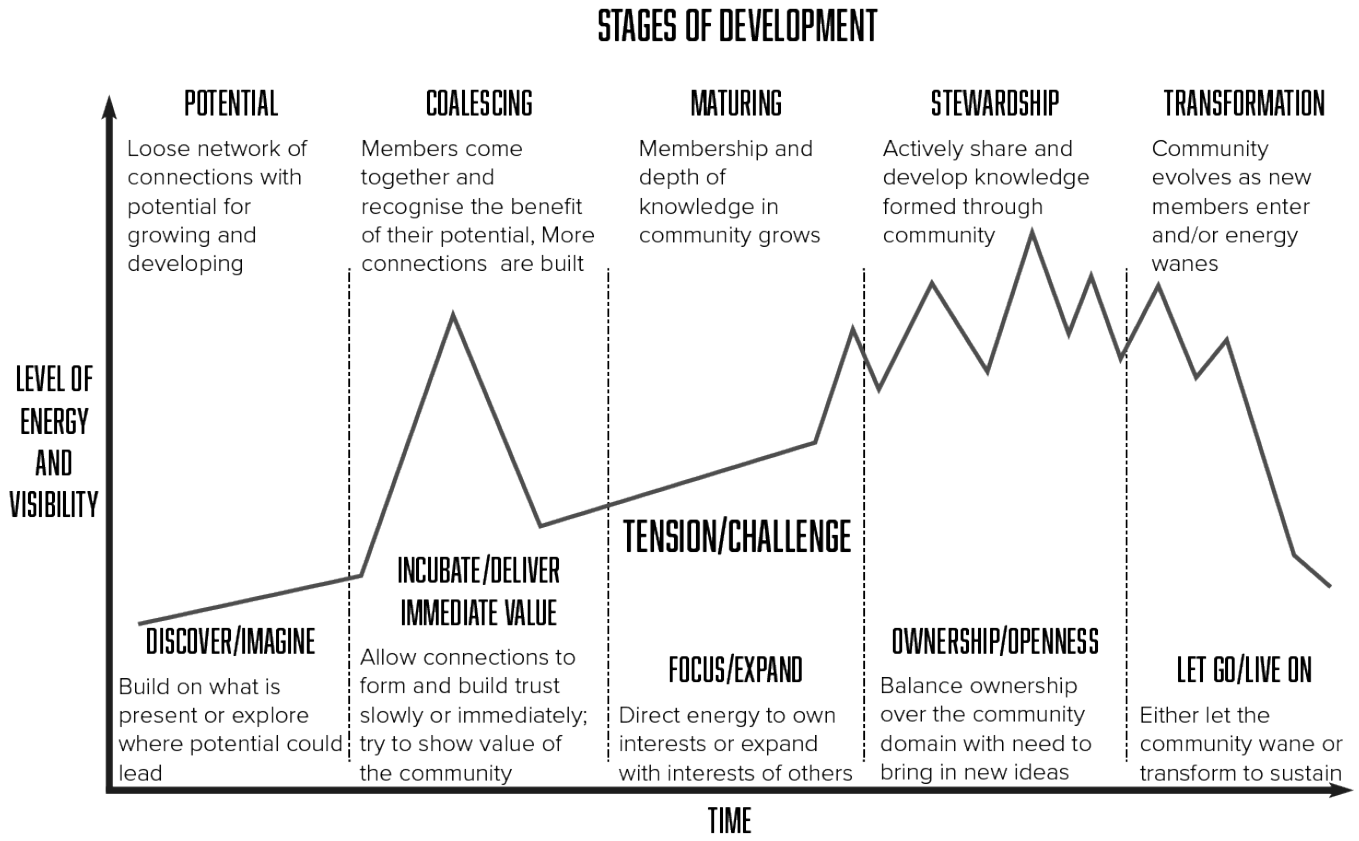

Figure 3. Stages of development in a community of practice. Adapted from Wenger, McDermontt, and Snyder (2002)

The quantitative data used in the social network analysis revealed the formation of a community of practice which was backed up by the qualitative data provided in the journals and feedback sessions. Using the *Stages of Development* described by Wenger, McDermott, & Snyder (2002) (Figure 3) it is clear that through the project there was a recognition of the **potential** at the start, and a **coalescing** during the delivery of the summer programme. The strengthening of ties in the social network analysis demonstrates the formation of the community of practice between different libraries. With support from the library management team to run events and discuss with colleagues, the researchers hope that the community of practice created will expand to include library staff who did not take part in the project and other interested stakeholders.

9 Conclusion

The project detailed here demonstrates just a small part of the move to stewardship. By providing library staff with the tools and time to create a community of practice around digital skills delivery, the research demonstrates that libraries are the ideal hub for towns and more rural areas to share ideas and practice around stewardship. Designers need to embrace their local libraries as locations of learning, and skill sharing. They should work with staff to create sustainable solutions. Collaborating with staff to establish communities of practice within libraries, accelerating the dissemination of skills needed for a circular future. Further research is to be undertaken, exploring other ways communities of practice are aiding the move towards a circular future and how these communities can include public stewardship in the fight for a better climate. While it is crucial for a circular and sustainable future that manufacturers become material stewards, it is also essential that we become stewards of the products we own. Good practice will ensure that these products last as long as possible, but it is up to designers to create products and systems of which consumers will want to become stewards.

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Children Deserve Better Public Life: Human-centred Design in Play Spaces

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ACCORDING TO the United Nations, children have the right to play. In the recent years, increasingly more researchers and designers have advocated the importance of quality play spaces for children. However, children are often neglected in the design of play spaces, with adults dominating the decision-making process. Children's needs for a public life are seemingly less imperative than those of other groups. However, increasingly more researchers have argued children need to have a meaningful and exciting public life in public spaces. Children interact with other children they do not know and make new friends in play spaces, where they develop their cognitive, emotional and social ability in play spaces. In short, a favourable public life in play spaces is crucial for their development. As the interaction and communication in these spaces depend greatly on their design, it is important to consider design as one of the decisive factors in determining the quality of children's public life. This paper argues that human-centred design in public spaces is essential for improving children's public life. Based on a case study of Hong Kong, the paper explores this issue by first reviewing the categories of play spaces and the related activities of children's public life. The paper then offers suggestions as to how children can live a better public life in human-centred design play spaces.

Keywords: Children; public life; play space; human-centred design; play interactions

1 Introduction

Adults have to take on direct public responsibilities and obligations for society's sake after entering the workforce. They also have the right to decide the extent to which they engage in public life after contributing to the economy. The government and non-government parties that design and build public infrastructure are adults and they consult exclusively with other adults. In other words, adults make all of the decisions on behalf of the public, which includes children who lack opportunities to express their opinions on public matters, unlike other minority groups. While issues such as public policy, welfare and finance are too complicated for children to fully understand, they should have the opportunity to provide opinions on the facilities and services designed specifically for them.

The public affairs closest to the lives of children are those involving the design of public spaces, such as public play spaces. As the term suggests, the major aim of a play space is to provide an environment containing facilities and services for playing and engaging

children in play (Brett, Moore, & Provenzo, 1993). Brett et al. (1993) describes play as child's work. According to Play Therapy, play is 'a physical or mental leisure activity that is undertaken purely for enjoyment or amusement and has no other objective' (Play Therapy United Kingdom, 2017). Gordon (2009) suggests that play is 'the shift from reality to a new play-specific space/time with its own rules of procedure' (p. 6). Play is also the attitude that triggers the shift. Interestingly, through this imaginary space/time, children learn how to cope with problems in the real world. Apparently, the definition of play is complex and ambiguous (Eberle, 2014). In this study, play was defined as any activity that is enjoyable for children. A broad definition was adopted to make sure that no play activity was excluded.

Article 31 of the Convention on the Rights of the Child states that 'states parties recognize the right of the child to rest and leisure, to engage in play and recreational activities appropriate to the age of the child and to participate freely in cultural life and the arts' (United Nations, 1990). Children have the right to play according to the Convention; however, they do not have opportunities to have a say on the design or development of play spaces (Brett et al., 1993). In other words, children are often marginalised, and little is done to involve them in the play-space design process. Yet a favourable public life in play spaces is crucial for their all-round development. Based on a case study of Hong Kong, this paper explores the issue by first reviewing play-space categories and the corresponding activities of children's public life. Based on the findings, the paper suggests how children can live a better public life through human-centred play-space design. It is believed that optimising play-space design will provide children with the public life they deserve.

2 Method

2.1 Sample Play Spaces

Hong Kong has a very high population density, with most people living in crowded residential areas. Play spaces in the city are often full of different kinds of people, and various incidents occur within them (Siu, Wong, & Lam, 2018). This unique situation provides a rich source of data that other cities may be unable to provide.

The play spaces in Hong Kong's Kwun Tong District were chosen for this study. Kwun Tong had the highest overall population density in Hong Kong during 2011 (55,204 people/km^2) and its density of children aged 12 and below was also the highest (5,325 children/km^2) (Census and Statistic Department, 2015). The district was chosen because it could reflect the typical environments and phenomena in the city's play spaces. To gain a holistic understanding, four other popular play spaces were also visited, located in Tuen Mun in the New Territories, Sham Shui Po in Kowloon, Quarry Bay on Hong Kong Island, and Inspiration Lack on the Lantau Island.

There are 105 play spaces in Kwun Tong District, with play equipment having been installed in 85 of them. These 85 public play spaces are managed by either the Leisure and Cultural Services Department (LCSD; 24 spaces), the Housing Authority and Housing Department (HA and HD; 52 spaces) or the private sector (9 spaces). All these play spaces are open to the public, making it easy for nearby residents to access them.

2.2 Procedures

The 85 play spaces were identified through a number of field studies in Kwun Tong District (see the Note). In all of the spaces, participant observations were conducted. The entire

research process, including field studies, data collection and analysis, lasted from 2016 to 2018.

During the study, the researchers detached themselves from the play spaces and observed the behaviour of the children and their adult caretakers. They then talked to caretakers' groups about their children. Photos were taken, and semi-structured and unstructured interviews were conducted with the caretakers and the children. The questions were related to the time of day the caretakers typically brought their children to the selected play spaces, the games the children played and other activities the children engaged in once there. The researchers also interviewed the older children to understand their activities. Questions such as 'what are you playing?' and 'what are the rules of your game?' were asked. The interviews were conducted in groups. While the interviewers kept in mind the importance of obtaining individual responses, group interviews were helpful in that they eased the nervous tension of both the children and their caretakers. Similar data collection processes were conducted in the 85 play spaces, and the data set approached saturation after interviewing 10 caretakers and around 25 children. The researchers stayed for at least an hour at each play space on weekends or weekdays after school at about 4 pm. The children and their caretakers usually went to play spaces on the weekends or after school, i.e., at around 4 pm. Some of the children went to play spaces next to their homes unaccompanied by caretakers. Children often returned home at around 6 pm or until sunset.

3 Findings

3.1 Play Space Categories

In parallel with city development, different kinds of play spaces emerge, depending on particular social issues and needs. These spaces have various designs and different degrees of popularity. Brett et al. (1993) separates play spaces into four categories according to their facilities, environments and purposes: traditional, designer, adventure and creative playgrounds. However, the findings of the field studies in Kwun Tong District suggested that such categorisation does not apply to Hong Kong. For instance, due to the intensive using and high demanding of lands, adventure playgrounds are unpopular in the city. This situation is also common in other densely populated cities. On the other hand, a few of these available adventure playgrounds are also far from living environments. Hence, after some research meetings with the government official, professional planners and designers and NGOs serving the children' needs and according to the field work findings, four new categories of play spaces were identified based on the field studies. They are (1) cramped play spaces, (2) one-size-fits-all play spaces, (3) designed play spaces, and (4) participatory play spaces. Cramped play spaces refer to public play areas with very limited number of play facilities. One-size-fits-all play spaces refer to public play areas with one or several sets of composite play structure in a larger area. The design of this kind of play spaces are the same across districts. Designed play spaces is defined as the public play spaces with newly design elements. These design elements are distinct from the features of typical composite play structure. Users of cramped play spaces, one-size-fits-all play spaces, and designed play spaces take a passive role in the design process. However, participatory play spaces involves users and allows them to provide opinions in the design process. Table 1 below shows the descriptive statistics of play spaces in the four categories in Kwun Tong District. It is noted that the four other popular play spaces visited are not included in Table 1. Table 2 shows the number of play facilities found in the play spaces.

These data were collected based on the field study and the data provided from the government websites,

Table 1 Descriptive statistics of play spaces in different categories in Kwun Tong District

Play space category	Camped play space	One-size-fits-all play space	Designed play space	Participatory play space
No. of play spaces	57	24	4	0
No. of play space spaces managed by LCSD / HA and HD / Private sector	0 / 52 / 5	20 / 0 / 4	4 / 0 / 0	0 / 0 / 0
No. of play facilities on average	7	15	23	-
Most popular play facilities in the play spaces	Climbing facility	Climbing facility	Climbing facility	-
Least popular play facilities in the play spaces	Merry-go-around	Merry-go-around	Dramatic play facility*	-

** Dramatic play facility refers to structures decorated as houses or castles.*

Table 2 Number of play facilities found in the play spaces in Kwun Tong District

Play space category	Camped play space	One-size-fits-all play space	Designed play space
Climbing	182	147	28
Slide	98	70	9
Cognitive games	57	77	21
Rocking chairs	34	36	9
Swing	12	19	4
Facility related to the 5 senses	11	17	8
Seesaw	8	8	7
Dramatic play facility	7	3	3
Merry-go-around	5	2	4

3.1.1 Cramped play spaces

When Hong Kong was governed by the United Kingdom, various social issues compelled the government to develop the city and quickly build facilities. The colonial government then built play spaces to address the high rates of truancy and child crime (Fung, 2008). In the 1930s and 1940s, play spaces were built out of concrete (Kwok, 2003), and most of the facilities were for climbing. In the 1950s, in response to rapid population growth, the government built public housing and gradually added adjacent play spaces with facilities including swings, slides, roller slides and climbing apparatuses, some of which were more dangerous than those used today. The materials commonly used were metal, wood or plastic. Most such play spaces have been rebuilt or dismantled, but some still exist. Composite play structures, purchased from the US or UK, were then assembled on sites. It was observed in the field studies that because these older play spaces are small, it is common for the composite structures to have only one slide and few climbing apparatuses. The interviewed children said that did not find this kind of play structure to be challenging.

As the population continued to grow, New Towns in the New Territories were developed in the 1950s (Siu, 2001). Old residential areas were transformed into new public housing estates and some small play spaces were built nearby. Composite play structures were again used (Figure 1). The environments of the remaining spaces in this category are crowded and some are even positioned under buildings (Figure 2). In larger play spaces,

some inclusive play facilities are included (Figure 3). These play spaces, along with the older play spaces mentioned above, are still managed by the HA and HD.

Figure 1. Composite play structure in a play space next to a public housing estate

Figure 2. Composite play structure under the eaves of a building on a public housing estate

Figure 3. Inclusive play facilities in a play area next to a public housing estate

3.1.2 One-size-fits-all play spaces

During the 1990s, the LCSD began building and opening one-size-fits-all play spaces. According to the field studies, these play spaces are much larger and also with diverse play facilities than their older counterparts. Most are in parks alongside other facilities such as bicycle tracks, jogging trails and elderly fitness stations, allowing children can run back and forth among different facilities.

Almost all of these play spaces consist of composite play structures, and they usually include slides, climbing facilities and swings. The scale of these spaces is much larger than those next to housing estates mentioned above (Figure 4). However, the designs of such spaces are similar across districts in Hong Kong (Siu, Wong, & Lam, 2017). During the field studies it was obvious that the type of play facilities appeared repeatedly across spaces in slightly different forms and colours without having any connections with other areas of the parks. Other facilities supporting the play spaces were also inadequate.

Figure 4. One-size-fits-all play space with composite play structure

3.1.3 Designed play spaces

After 2000, the government noticed that many buildings in urban areas were aged and had safety issues (Urban Renewal Authority, 2017). Some areas also needed to be revitalised or redesigned so that people could live better lives. Under the government's urban redevelopment plans, some areas in Hong Kong were transformed into recreation parks with different kinds of facilities such as performance areas, viewing pavilions and amenity lawns. Play spaces were also included among the facilities in these parks. Field observations of such spaces indicated that the facilities within them are new and that they allow children to play in their own ways. For instance, the play facility in Figure 5 is a wave that can be changed by pressing down or lifting up the component at the end. This kind of play space often includes other play facilities and structures that provide sensory and cognitive stimulation.

Figure 5. Play facility in the Designed Play Space

This type of play space is much larger than the others mentioned above. The distance between each piece of equipment is large enough for children to run around in safety. These play spaces are also well attached to the surrounding environments with different kinds of leisure facilities next to them.

3.1.4 Participatory play spaces

Although participatory design (otherwise known as community design) has been advocated for several decades, participatory design of public environments with and by children is new to Hong Kong. Play spaces designed with the participation of children have either (1) involved children in the actual design process, such as Tuen Mun Playground in Tuen Mun Park (Figure 6), or (2) been constructed with materials that allow children to build their play spaces, such as the 'Community Build Playground' organised by Playright Children's Play Association at Inspiration Lake on the Lantau Island (Figure 7). In the first type, children were invited to design their dream play spaces. Architects and designers talked to the children and gained thorough understandings of their designs. They then used the children's design ideas and designed a set of play facilities. Positive feedback was usually gained after the participatory design process.

In the second type of space, children are given building blocks to build play equipment by themselves in a designated play area (Figure 7). They can build and dismantle the blocks easily so that they have a large variety in their play over a very short period. This kind of play space is often temporary and is most often used by non-governmental organisations to promote play in the community. The organisations rent lawns or large areas to allow children to play freely with the building blocks, which are usually recyclable materials or foam cubes that children can handle easily.

Figure 6. Play equipment in Tuen Mun Playground at Tuen Mun Park

Figure 7. Children building their own play facilities at an event called 'Community Build Playground' organised by Playright Children's Play Association at Inspiration Lake (Photos credited to Playright Children's Play Association)

3.2 Activities in Play Spaces

It was observed that children spent several hours a week in public play spaces, running, playing and talking with other children. In such spaces they met new friends and develop their interpersonal communication skills; they faced new challenges and cultivate their problem-solving skills; and they participated different kinds of play activities and developed their cognitive, physical and social abilities (Jeanes & Magee, 2012). Children created their own rules and communication methods in play spaces, contributing to one another's development. Clearly, play spaces are important in socialisation, the process by which children learn moral and social values (Denzin, 1975).

Maxwell, Mitchell and Evans (2008) summarised different types of play and social interaction behaviour, and identified five kinds of play behaviour and four kinds of interaction behaviour. The play behaviour includes dramatic/fantasy play, constructive play, functional play, games

with rules, and non-play. The interaction behaviour includes solitary, parallel, positive and negative interactions. All of the behaviour, which also relate to the public life of children, were observed in the field study. Apart from addressing each activity, the followings highlight two distinct findings in the observation. Higher level of play and other social activities are also highlighted below.

3.2.1 Running as a universal play activity

Running itself is a kind of play for younger children that can also help children work off their surplus energy. The surplus energy theory suggests that surplus energy is released through aimless play (Evans & Pellegrini, 1997). In addition, at this level of play, where rules do not exist, the element that makes running so much fun is the freedom children can enjoy. This helps them to lose the inhibitions and release the pressure of their daily lives (Mellou, 1994).

Nearly all of the children observed in this study ran in the play spaces. Older children played other games such as hide-and-seek but after that they started to play tag. Many of the other play activities or games observed were also based on running. The children could run anywhere without any restrictions, and they showed their delight in their happy faces. Although numerous caretakers (particularly appointed caretakers and not parents) urged the children not to run too fast, many of the children were able to run freely in the play spaces.

In the interviews, the caretakers suggested that running was more acceptable than other aimless activities such as jumping off play facilities or rolling on the ground. Running was comparatively safer, and caretakers could easily foresee the potential danger in front of the child.

3.2.2 Children's levels of dominance of the play equipment

The observed children understood and used play facilities differently. For instance, younger children followed the form and function of the play facilities. They slid down slides or climbed climbing apparatuses. In other words, the play facilities controlled/guided them. These children were 'followers', and the play facility could be regarded as a 'controller'.

Many older children, however, did not follow form and function. Instead, they challenged them. For instance, some walked up slides or twisted swings. Although this was dangerous in a certain sense, the children were creatively exploring new ways of play based on the forms of the facilities. In other words, sometimes play equipment could stimulate their creativity. These children were 'explorers', and the play facilities could be regarded as 'stimulators'.

Some children did not consider the facilities as specific play apparatuses. For instance, although some understood that certain parts of the composite play structures were slides, they used them as chunks of plastic in the play space. Therefore, they jumped across the slides and stood on the railings to practise their balance. They created new functions based on the affordance of the play facilities. These children were 'creators', and the play facilities can be regarded as 'providers'. Figure 8 shows the children's levels of dominance of the play equipment.

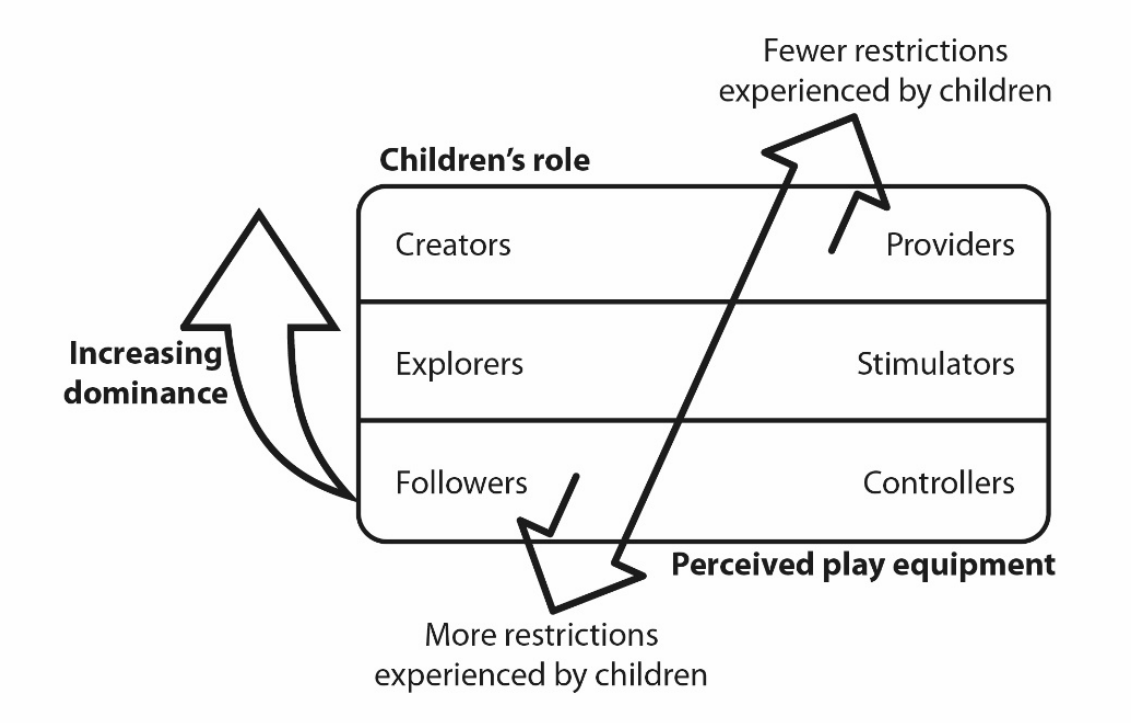

Figure 8. Children's levels of dominance of play equipment in play spaces

The children became more explorative and creative when they perceived the forms of play facilities as being less functional and meaningful. They also experienced fewer restrictions when playing. Usually, before becoming 'creators', most of the children had at one point been 'followers' and 'explorers' until they found the equipment to be boring. They then invented new ways of playing on the facilities.

3.2.3 Other play and social activities

When children begin to develop their ability to understand abstract ideas and concepts, imaginary play becomes the most popular game. Imaginary play is extremely popular among children everywhere, even those with disabilities (Harris & Jalloul, 2012). Siu, Wong and Lam (2018) show that imaginary play is very popular in play spaces.

The observed children's imaginary play included chasing, hide-and-seek, make-believe and playing 'the floor is lava', with more crowded play spaces giving rise to more diverse play activities. The children were both players and referees, and checked on each other to see whether anyone had broken the rules. Yet the rules changed on a daily basis. Still, not anyone was able to change the rules, and some children refused to follow new rules. Power struggles and tension emerged.

4 Discussion: Children's Public Life and Human-centred Design

4.1 Human-centred Design in Play Spaces

According to Lii (1988), strangers, who are individualistic and self-centred, interact to maintain public life. Similarly, children interact with others in play spaces, which become the environment in which their public life takes place. Children who do not know one another participate in a form of self-organisation, suggesting that play is the source of public life. Play connects children and provides a reasonable justification for children, and their caretakers, to share their lives.

In this study, the researchers observed that children's play activities were not limited by the category of play space in use, but the quality of play was. For instance, running and imaginary play could happen in any play space. Even in cramped play spaces, children could make-believe they were on boats at sea. They could also run around the play facilities and have fun. However, in such limited spaces, they could not run for long or risk crashing into one another. They became bored of being followers, their sense of enjoyment lessened and their interactions decreased. Given that play-related interaction and communication depend greatly on the design of the play space, it is very important to consider design as one of the decisive factors in the quality of children's public life.

Indeed, the findings of this study indicate the need for human-centred design in play spaces. In order words, children have to be at the centre of the design, with their interests given high priority and their needs taken into consideration. This will allow them to experience a better and more enjoyable public life when they are at play with other children. Obtaining first-hand information from children regarding their interests and motivations is the best way to create such human-centred play spaces. Having a better public life at an early age will help to develop children's capabilities to handle different kinds of relationships and cope with pressure. Children deserve to have such experiences with others in well-designed play spaces.

4.2 Towards a Better Public Life

Considering the child-equipment relationship derived from the children's dominance of play facilities shown in Figure 8, the explorer-stimulator and creator-provider relationships facilitate the most human interaction. More interactions among children in a human-centred environment result in more intense public life. However, having a more intense public life does not imply that it is more enjoyable. Factors such as other facilities and caretakers also need to be considered. That is why caretakers should be encouraged to accompany children in play spaces, so they can provide adult supervision and help the children to handle a full range of emotions.

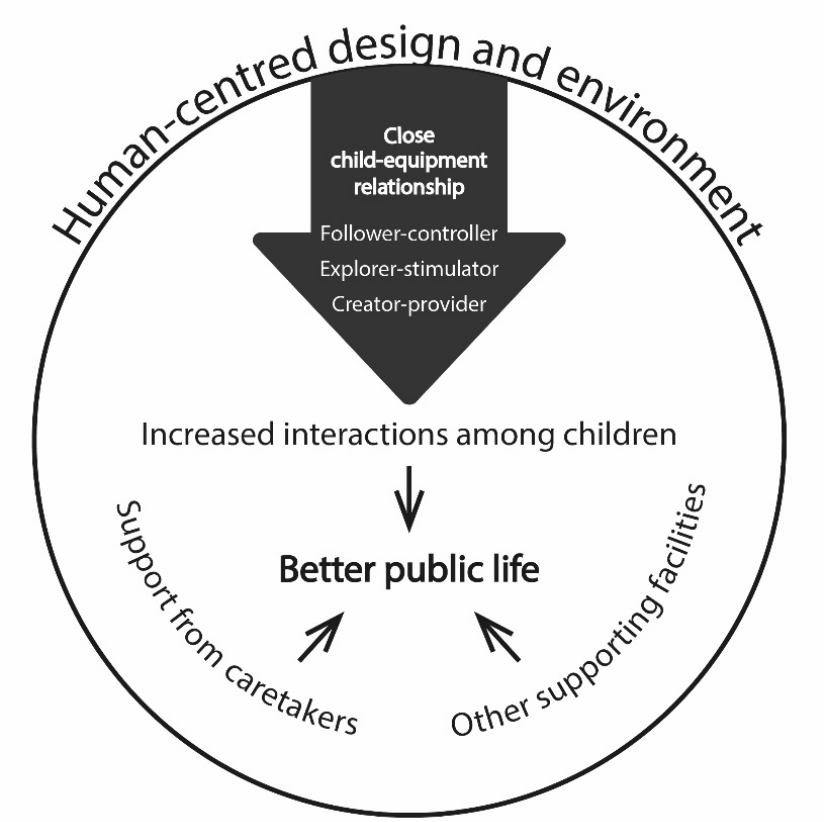

Figure 9. Attainment of better public life in human-centred play space environments

Figure 9 shows that interactions among children increase with the shift from 'follower-controller' to 'creator-provider' relationships in human-centred play spaces. These increased interactions, supported by other facilities and caretakers, help children to enjoy a better public life. Human-centred design (represented by the circle in Figure 9) is vital for maintaining a close relationship between children and equipment, and between children and play spaces. Without this close relationship, offering a better public life in play spaces will remain a challenge.

Although it may seem obvious that public facilities should be human-centred, such is not the case for play spaces. Children are usually not at the centre of the design process. The play equipment and the landscape layout are designed with children in mind, but it is questionable whether children actually enjoy them. According to the field observations in this study, cramped play spaces and one-size-fit-all play spaces suffer from this deficiency, resulting in younger children only following the form of the play facilities. Even when designed play spaces were observed, there was no evidence that children were at the centre of the design. The role of children's play in the design was found to be ambiguous and sometimes undervalued.

According to Wong, Lam and Siu (2018), most designs of play spaces in Hong Kong do not facilitate social interaction among children. Based on the findings of the present study, only the participatory play space design is centred on children and their needs. Children's opinions are valued in the design process, and the play environment is motivating. It can be argued that the design process is the major depository of human-centred design, and the play facilities are the tangible results of a human-centred process.

Approaches of participatory design varies. Druin (2002) suggested that children contribute to the design process in four different roles: user, tester, informant, and design partner. Although participatory play space can be achieved through involving children in any of the four roles, more participation of children in the design process, i.e., children as design partners, is more able to put children's feedback and opinion into practice. Different stakeholders and designers can join children and form different groups to generate different ideas for human-centred design.

5 Conclusion

Play spaces are places where children live their public life: they encourage social activities among children from different backgrounds and with different abilities (Siu, Wong, & Lam, 2016). In play spaces, children learn how to play with other children they do not know and make new friends. They play together to develop their cognitive, emotional and social abilities. This play also helps children to relieve the pressures of daily life. Although playing allows children to escape from reality, this specific space and time represents the reality of their public life. In this constructed reality, children practice how to become adults in the future. This explains why the United Nations, backed by the research of social and health organisations, places such a high value on children having play as a basic right.

The findings of this study show that children run and play in play spaces and use the facilities in different ways. Different kinds of child-equipment relationships suggest that children's creativity, as seen in their inventing new games, may either be encouraged or restricted by the design of the equipment. This, in turn, affects the quality of their public life. It is thus important that the design of play spaces takes children's needs into consideration.

Children have to be involved in the process of designing play spaces so that a human-centred play space, such as the participatory play space, can be built. Children's active participation in creating play spaces also contributes to a community's sense of social cohesion (Brett et al., 1993). However, children are often neglected in the design process, and adults make most of the decisions on their behalf. In Hong Kong, the design processes of only a few play spaces have involved the participation of children. Yet children deserve a better public life, and to that end human-centred play space design is vital.

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Note: The 85 visited play spaces are categorised below according to parties that manage them. Those not given names by the managing parties are named according to their locations.

The 24 visited play spaces managed by the LCSD were:

- Kwun Tung Promenade
- Choi Hei Road Park
- Choi Wing Road Park
- Hiu Kwong Street Rest Garden
- Hiu Ming Street Playground
- Hong Ning Road Recreation Ground
- Jordan Valley Park
- Kowloon Bay Sports Ground
- Kung Lok Road Children's Playground
- Kwun Tong Recreation Ground
- Laguna Park
- Lam Tin Park
- Lok Wah Playground
- Ngau Tau Kok Park
- Ngau Tau Kok Road Children's Playground
- Ping Shek Playground
- Sai Tso Wan Recreation Ground
- Sam Ka Tsuen Recreation Ground
- Sau Ming Road Park
- Sau Nga Road Playground
- Shun Lee Tsuen Park
- Shun Lee Tsuen Playground
- Yau Tong Road Playground
- Yuet Wah Street Playground

The 52 visited play spaces managed by the HA and HD were:

- Car Park Playground, Choi Fook Estate
- Choi Foon House Playground, Choi Fook Estate
- Choi Sin House Playground, Choi Fook Estate
- North-East of Choi Hay House Playground, Choi Fook Estate
- North-West of Choi Hay House Playground, Choi Fook Estate
- South-West of Choi Hay House Playground, Choi Fook Estate
- Choi Chun House Playground, Choi Tak Estate
- Choi Shun House Playground, Choi Tak Estate
- Ying Fu House Playground, Choi Ying Estate
- Kwong Hin House Playground, Kwong Tin Estate
- East of Lei Sang House Playground, Lei Yue Mun Estate
- Lei Lung House Playground, Lei Yue Mun Estate
- North of Lei Sang House Playground, Lei Yue Mun Estate
- West of Lei Sang House Playground, Lei Yue Mun Estate
- Kwai Sun House Playground, Lower Ngau Tau Kok Estate
- Kwai Yuet House Playground, Lower Ngau Tau Kok Estate
- North of Kwai Leung House Playground, Lower Ngau Tau Kok Estate

- South of Kwai Sun House Playground, Lower Ngau Tau Kok Estate
- Ping Mei House Playground, Ping Tin Estate
- Ping Sin House Playground, Ping Tin Estate
- East of Tat Yi House Playground, Po Tat Estate
- North of Tat Fu House Playground, Po Tat Estate
- North of Tat Fung House Playground, Po Tat Estate
- North of Tat Yan House Playground, Po Tat Estate
- North of Tat Yi House Playground, Po Tat Estate
- South of Tat Yan House Playground, Po Tat Estate
- South of Sau Hong House Playground, Sau Mau Ping Estate
- South of Sau Nga House Playground, Sau Mau Ping Estate
- South of Sau Yee House Playground, Sau Mau Ping Estate
- East of Sau Wai House Playground, Sau Mau Ping Estate
- North of Sau Nga House Playground, Sau Mau Ping Estate
- North of Sau On House Playground, Sau Mau Ping Estate
- North-East of Sau Yin House Playground, Sau Mau Ping Estate
- South of Sau Ho House Playground, Sau Mau Ping Estate
- South of Sau Yin House Playground, Sau Mau Ping Estate
- Sau Mau Ping Shopping Centre Playground
- Lee Cheung House Playground, Shun Lee Estate
- On Chung House Playground, Shun On Estate
- On Yat House Playground, Shun On Estate
- Tin Wing House Playground, Shun Tin Estate
- Tak Lai House Playground, Tak Tin Estate
- Tsui Lau House Playground, Tsui Ping Estate
- Tsui Mui House Playground, Tsui Ping Estate
- Tsui Nam House Playground, Tsui Ping Estate
- Sheung Yat House Playground, Upper Ngau Tau Kok Estate
- Wo Lok Estate Playground
- East of Tsui Lai House Playground, Yau Lai Estate
- Hong Lai House Playground, Yau Lai Estate
- North of Tsui Lai House Playground, Yau Lai Estate
- Yung Lai House Playground, Yau Lai Estate
- East of Kwai Tong House Playground, Yau Tong Estate
- West of Kwai Tong House Playground, Yau Tong Estate

The nine visited play spaces managed by the private sector were:

- Po Pui Court Playground
- Domain Mall Green Root Garden
- East of Lai Nga House Playground, Hong Nga Court
- Lai Nga House Playground, Hong Nga Court
- West of Lai Nga House Playground, Hong Nga Court
- Chung Pak House Playground, Hong Pak Court
- Laguna City Playground
- Telford Gardens Block Q2 playground
- Telford Gardens Block S2 playground

Defining urban graphic heritage for economic development in the UK and China

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What new perspectives can graphic design contribute to design for heritage? This paper provides answers to this question by confirming the meaning of heritage and the value of research in the context of a vibrant and evolving creative industries in the United Kingdom and China. Heritage has become an important topic for research in recent decades, and now features as a priority area with research councils. Increasingly, it is framed as cultural heritage, but the meaning of culture is unclear. In outlining the challenges associated with rapid urban development in China, and the importance of design, planning and heritage, a framework for analysing urban graphic heritage is proffered alongside empirical research from the United Kingdom and China. Despite its importance being overlooked in heritage discourse as well as contemporary reviews of the creative industries, graphic design is shown to provide a unique overarching perspective for the design challenges associated with the human experience of urban heritage.

Keywords: China, heritage, graphic design, creative industries

1 Introduction

The consideration of graphic design as a cultural object in cultural heritage has gained in prominence through the recent staging of the conference 'Graphic Design as Cultural Object: History, Heritage and Mediation in the Digital Age' (http://www.museologiadesign.it/gdco-conference-2018/). This highlighted the role of graphic design objects in the name of 'preservation, interpretation, mediation and circulation' for scholars, researchers, practitioners and students interested in the fields of graphic design history, design and design culture, communication sciences, advertising studies, archival and museum studies and practice, graphic design and interaction design.

In this paper we set out a framework for integrating an understanding graphic design as fundamental in the relationship between design and heritage. This is contextualised against the recent importance of prosperity and growth of the so-called creative economy in the United Kingdom (UK) and China, and the aspirations for future collaborative research and innovation partnerships between the two countries.

First, we outline the research focus by examining the meaning of heritage, the recent emergence of heritage in arts and humanities research, the evolution of the creative industries, the role of the UK in supporting the development of creative industries strategies in China, and the importance of graphic design as a creative industries practice in what might be called 'urban graphic heritage'. Building on this, the paper provides some research context with a short introduction to urban development in China, a focus on Shanghai's status as a designated 'City of Design', before emphasising that urban planning must be more acquainted with design and design literacy for the benefit of heritage management. Finally, we show how graphic design can be used to provide a distinct perspective on heritage, for establishing what has been referred to in 'systemics' as 'essential relationships' and 'critical connections' (Nelson and Stolterman 2012: 57–91) between heritage, the creative economy and development, for the representation of urban heritage.

2 Research focus

In this section we clarify what is meant by heritage, how heritage and research is currently aligned, and the importance of graphic design to the creative industries.

2.1 What is heritage?

A first, universal, definition of heritage is attributed by Vecco (2010) to the International Charter of Venice in 1964, for the purpose of conservation and restoration of monuments and sites:

> Imbued with a message from the past, the historic monuments of generations of people remain to the present day as living witnesses of their age-old traditions. People are becoming more and more conscious of the unity of human values and regard ancient monuments as a common heritage. The common responsibility to safeguard them for future generations is recognized. It is our duty to hand them on in the full richness of their authenticity is found (Vecco 2010: 322).

Since 1964, heritage has come to stand for much more than monuments and sites. Now, and generally speaking, heritage is understood to be the inheritance of 'property', either from the perspective of what is or what might be inherited. Property in this sense relates to something tangible, intangible or natural. For example: a building, a trait, an attribute, or an aspect of nature. In short, such properties are valued objects, qualities or environments inherited from previous generations.

Examples of tangible and intangible heritage are, typically, the preservation of buildings, or a spoken language. For instance, in the UK, historic buildings are protected by the Government and may not be demolished, extended, or altered, without permission from the local planning authority. Similarly, a spoken language may be protected by law, as is the case in the UK whereby in one of its constituent countries, Wales, the Welsh language is given equal prominence to English language in the management of public affairs. The point is accentuated when considering that approximately 60 million people in the UK speak English, whereas much less than one million people speak Welsh.

In essence, tangible heritage is commonly understood to define, for example, historical sites, buildings, monuments, objects in museums, artefacts and archives, whereas intangible heritage may be comprised of customs, sports, music, dance, folklore, crafts, skills, and knowledge. Natural heritage is often thought about in relation to waterways, landscapes,

woodlands, bogs, uplands, native wildlife, insects, plants, trees, birds and animals. This paper is mostly concerned with tangible heritage and the objects that constitute the urban environment.

Heritage, both tangible and intangible, in relation to the urban environment, has recently gained in global prominence with the publication by United Nations of the New Urban Agenda (www.habitat3.org), something also referred to as Habitat III. Within this document, heritage is directly linked to a number of important environmental themes: 'sustainable urban development', 'social inclusion', 'poverty', 'inclusiveness', 'prosperity', 'opportunity', 'planning', 'management', and 'urban spatial development'. In Habitat III, heritage is mentioned in terms of 'natural and cultural heritage', 'cultural heritage and local resources', 'performing arts and heritage conservation activities', 'preserving cultural heritage', 'cultural heritage and landscapes', and 'cultural heritage for sustainable urban development'. In this context, a contemporary understanding of heritage requires a grasp of the 'cultural' in relation to heritage.

In this scenario, 'Culture' and 'heritage' are closely linked to the extent that discussion about tangible and intangible heritage is increasingly framed as 'cultural heritage'. However, notwithstanding the difficulty associated with the word 'culture' (Williams 1988 [1976]), a concern for the safeguarding of cultural artefacts is an ancient idea that first became a legal matter for the protection of monuments and works of art in fifteenth-century Europe (Blake 2000). For some time now it has been understood that, more than monuments and works of art, culture may refer to 'intellectual, spiritual and aesthetic development, … a particular way of life, whether of a people, a period, a group, or humanity in general, … [or] the works and practices of intellectual and especially artistic activity' (Williams 1988 [1976]: 87–93). It would therefore be reasonable to assume cultural heritage to be inheritance associated with this three-part understanding of culture. That said, the diverse nature of cultural heritage is a complex matter. In essence, '… cultural heritage consists of manifestations of human life which represent a particular view of life and witness the history and validity of that view' (Prott and O'Keefe 1992: 307). Contemporary definitions of culture now make explicit the relationship between heritage and culture, and the importance of culture in the purpose and consumption of heritage: 'Heritage is a version of the past received through objects and display, representations and engagements, spectacular locations and events, memories and commemorations, and the preparation of places for cultural purposes and consumption' (Waterton and Watson 2015: 1).

Cultural heritage, then, is seemingly a flexible idea related mostly to the tangible and intangible, and natural things when they are considered sufficiently important to people for the purpose of preservation and inheritance.

2.2 Heritage and Research

Heritage has been an important focus for research during the past three decades, through what has been referred to as 'heritage studies' (Waterton and Watson 2015: 1). Furthermore, it has recently become a key area for research funding in the arts and humanities in the UK. For example, in the UK, the Arts and Humanities Research Council Strategy (AHRC) for 2013–2018 gave priority 'to enhancing partnership working in design, heritage, the exploitation of digital technologies and the museum, galleries and performing arts sectors' (Anon 2013: 24). AHRC has positioned their commitment to heritage as something that contributes to the so-called 'creative economy', placing heritage alongside design, the

creative arts, museums, libraries, galleries, publication, performing arts sectors. Furthermore, heritage is explicit in two of the themes outlined in the AHRC strategy: the *Care for the Future* theme, which aspired to the generation of 'new understanding of the relationship between the past and the future and how we transmit and question of heritage'; and *Connected Communities*, in relation to multidisciplinary research linkages between as 'key areas such as design, digital and heritage (2013: 15). Specifically, AHRC aspire to facilitate arts and humanities research to enhance business performance in creative, cultural and heritage sectors through research. This commitment to heritage is continuing to flourish in the UK through a commitment to 'the art, literature and history of the UK and of other countries around the world' (Anon 2018).

2.3 'Cultural industries' and 'creative industries'

Difficulty with the meaning of the word culture has been noted above. However, this is a complex matter in what has become known as the 'cultural industries'. Cultural industries is a contested term because of the different interpretations of 'culture'. Its origin is the plural equivalent of what had become known in the mid-twentieth century as 'The Culture Industry', which came to prominence in the work of Theodor Adorno and Max Horkheimer in the 1940s. Then, as the result of industrial commodification, culture industry referred to the diminished status of culture as a high form of artistic expression through human creativity (Hesmondhalgh 2002: 15). Over time, 'cultural industries' came to more accurately represent the complex variety of cultural production, in recognition of the opportunities associated with the commodification of culture (2002: 16).

By the beginning of the twenty-first century, the core of cultural industries encompassed a number of clearly defined sectors. These included: advertising and marketing, broadcasting, film, internet, music, print and electronic publishing, video and computer games. These sectors were integral to what had then became known in Europe as the 'creative industries', also encompassing more 'craft-based' activity such as 'jewellery making, fashion, furniture design and household objects and so on' (2002: 12–14).

The creative industries provide the basis for what AHRC refer to as the creative economy, and in 2013 the United Nations recognised the sector's global importance:

> The creative economy is not only one of the most rapidly growing sectors of the world economy, but also a highly transformative on in terms of income generation, job creation and export earnings … when the creative sector becomes part of an overall development and growth strategy, it can contribute to the revitalization of the national economy where hybrid and dynamic economic and cultural exchanges occur and innovation is nurtured. But this is not all. Investing in culture and the creative sector as a driver of social development can also lead to results that contribute to the overall wellbeing of communities, individual self-esteem and quality of life, dialogue and cohesion. (UN Report on Creative Economy 2013, cited in Bazalgette 2017)

An independent review of the Creative Industries sector (Bazalgette 2017) in the UK in 2017, and the sector's contribution to the creative economy, identified nine sub-sectors: Advertising and marketing; Architecture; Crafts; Design; Film, TV and radio; IT, Software and Computer services; Museums, Galleries and Libraries; Music, Performing and Visual Arts; and Publishing. In this sector overview there is a clear link to the earlier definition of the core activity of the cultural industries, the most notable difference being the additional reference

to architecture, crafts and design, as well as the mention of video and computer games as creative pursuits. The inclusion of Architecture is to be expected, as is craft based activities such as the aforementioned jewellery, fashion, and furniture. However, in this revised listing, design refers only to the creative occupations and specialised activities of product design, fashion design and graphic design, as noted in the report 'Creative Industries: Focus on Employment, also published by the UK Government (Anon 2016: 26).

In further recognition that the creative industries sector is fervently expanding globally, and becoming increasingly important for the future, Bazalgette (2017) cites the UK's support for the development of Creative Industries strategies in Brazil, Mexico, Kenya, China, Vietnam, Japan, Korea, Nigeria, South Africa, Egypt and Turkey. Significant to the arguments outlined in this paper, "China's Five Year Plan has as a central theme the need to move from 'Made in China' to 'Designed in China'" (Bazalgette 2017: 13). By comparison, in the UK, the creative industries generate £91.8bn per year (www.thecreativeindustries.co.uk). In China, recent estimates suggest the creative industries are worth 2,723.5 billion CNY (approx. £305.27bn) (Anon 2017), but the industry is much less mature having only been recognised since 2004 (Keane 2009), and is often referred to as the cultural and creative industries sector.

If, as noted earlier, graphic design is overlooked in the way heritage functions, the importance of graphic design to the creative industries cannot be underestimated. For example, since the mid-1980s graphic design has been the most prominent aspect of creative industries practice (Julier 2014). It is, therefore, reasonable to speculate that as the creative industries in China prosper, so will graphic design. Any desire to link design with heritage, therefore, will benefit from a close understanding of the relationship between graphic design and heritage. This research is thus concerned with the delineation of urban graphic heritage to confront the cultural heritage challenges set out in Habitat III.

3 Research context

In this section we touch on the recent rapid urbanization in China, before introducing Shanghai's embracing of culture, creativity and design and the challenges of urban planning in relation to design.

3.1 Rapid urban development in China

Since the 1970s China has experienced rapid urbanization. Its towns and cities have experienced explosive growth as hundreds of new districts, cities, towns and neighbourhoods have been created to accommodate the hundreds of millions of Chinese migrating from rural to urban environments. New infrastructure and buildings, as well as the renovation of existing stock superseded earlier Soviet planning practices (Xue et al. 2011: 209) that dominated Chinese city development since 1949, had resulted in the relative stagnation of Chinese cities. During this time cities such as Shanghai became overpopulated and underdeveloped.

China's urban modernization policies after the so-called 'open-door policy' in 1978, when the country moved towards more active participation in world markets, hastened urban development but with physical, economic and social consequences. Old harbours and factories closed, traditional forms of manufacturing contracted, local shops and traditional businesses were lost due to competition from supermarkets and shopping malls, old houses demolished and displaced communities were forced to move to the outskirts of the cities.

Consequently, local communities have been unable to adapt and respond and many local customs and heritage has also vanished. More than a decade ago it was reported that people in China are ‘increasingly concerned about the lack of character displayed by new large-scale developments, not only in new satellite towns, but also in Shanghai's historical centre (Chen 2005: 237).’

For example, in Shanghai’s, Lujiazui is a prominent example of new urban development and one of the country’s most ambitious examples of urban development and economic transformation. Lujiazui typifies the spirit of China’s urban age and is not only described as a good example of urban design but is also credited as one of the first urban design developments in China (Xue et al. 2011: 232). Designed predominantly by European architects and reminiscent of a globalized architectural style, Lujiazui’s hybrid architecture reflects individualism, modernity and tradition (Lang 2005). See Figure 1. However, whilst this new metropolis is resplendent, critics suggest it lacks any references to its former local identity (Chen 2005). The conflict between global modernity and local distinctiveness is exemplified in Lujiazui and symptomatic of the current urban development challenges in China, and the need for sustainable development that balances environmental sustainability, economic efficiency and social need. Lujiazui is said to have been a project driven not only by market-driven imperatives but also ‘by the aspirations of a people as represented by their government officials’ (Lang 2005). However, the lack of concern in Lujiazui for the old in the face of the new – a characteristic of China’s urban development in general – suggests government officials have not appropriately represented local interest.

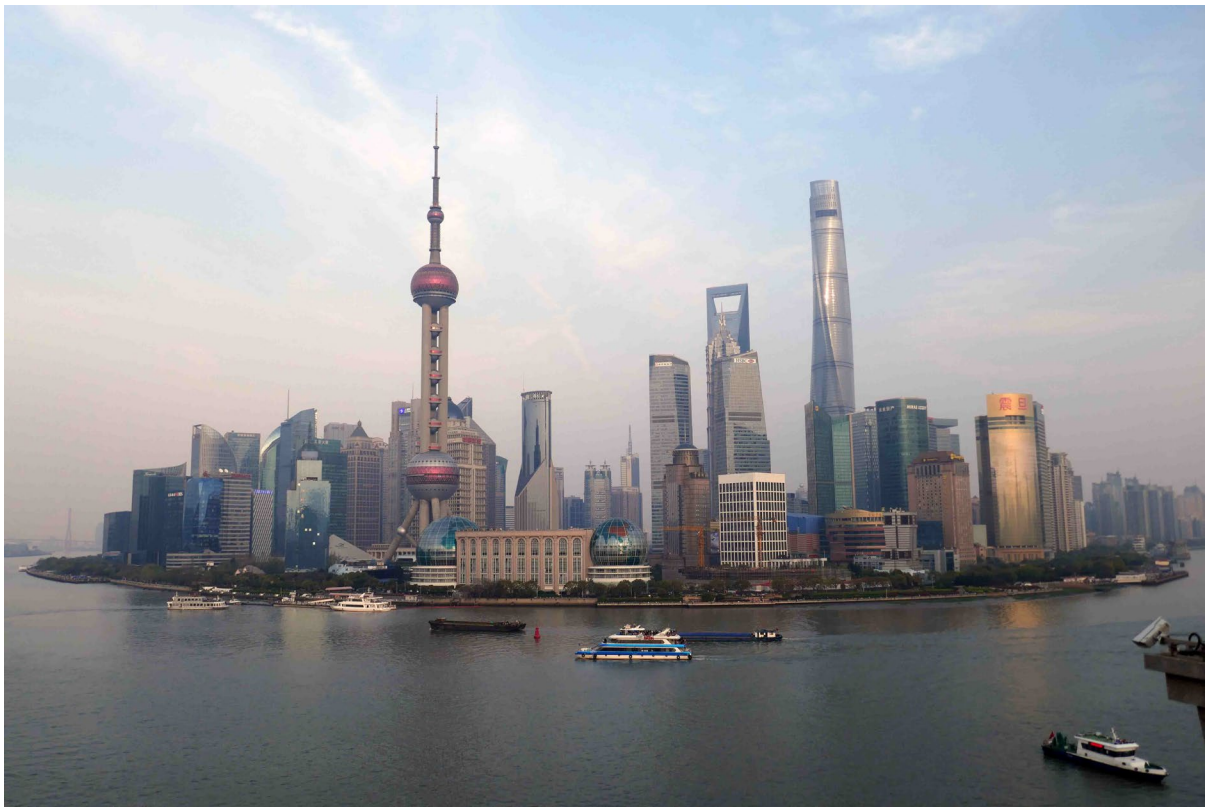

Figure 1. Shanghai’s Lujiazui, viewed from a rooftop on the Bund (Source: Robert Harland 2019).

In contrast, alternative approaches to regeneration have emerged with greater awareness for the physical and social consequences of urban development, such as the adaptive reuse of buildings, and more emphasis on preservation or building styles in the local vernacular. For example, Shanghai's Xintiandi neighbourhood is one of the earliest and most celebrated examples for the way development reflects the city's past, and the economic prosperity of modern life. See Figure 2. It is heralded as an example of development that integrates creative design with urban planning and construction development strategy. Both are highlighted as public/private development that foregrounds civil society and enhances Shanghai's status as a UNESCO 'City of Design'.

Figure 2. Shanghai's Xintiandi neighbourhood designed in the local vernacular (Source: Robert Harland 2018).

3.2 Shanghai City of Design

In 2010 Shanghai became a UNESCO 'City of Design', joining the UNESCO 'Creative Cities Network'. Since then the city has promoted the creative design industry for the benefit of urban renewal, industry transformation, improving the lives of citizens, international exchange and cooperation, and sustainable urban development. Throughout 2013–16 Shanghai introduced policies to integrate creativity and culture at a local level through public-private partnerships that link creative design to the economic, social and cultural development of the city. A number of institutions and design centres have formed, and Fashion and Interior Design have featured prominently in these initiatives.

During 2016–20 Shanghai's plan is to accelerate the integration of culture, creativity and design towards achieving the United Nation's 2030 Agenda for Sustainable Development.

Three areas of regional focus for creative design will facilitate this: (1) Focus on creative design promoting cross-boundary integration development; (2) Focus on creative design space construction to optimize spatial layouts; (3) Focus on fostering favourable environment for creative design. Design-driven urban renewal is at the heart of this change agenda. Consequently, Shanghai 'City of Design' reflects the United Nations on-going desire to encourage urban planners to 'help cities use design' (UN-Habitat 2008: 108), and the more recent UN Habitat III New Urban Agenda commitment to planning and managing urban spatial development. This calls for training urban planners at national, sub-national and local levels to improve the capacity for Urban Planning and Design.

3.3 Design, planning and heritage

As much of the urban development in China overlooks local traditions, this has led to a concern for more sustainable urban development that is socially responsible. Lujiazui and Xintiandi are proclaimed exemplars of design-driven urban renewal, but the former is said to be lacking in any sense of former local identity and is reminiscent of a globalized architectural style with its futuristic skyline. Hence, research that explores the relationship between design, planning and heritage is in need. But the wide-ranging nature of both design and planning mean that disciplinary focused responses are necessary.

The need to better understand the relationship between design and planning in China is also mirrored in the UK where there is a comparable necessity. In a recent review of the future of the built environment emphasis is placed on design quality and decision makers receiving training in design literacy (Farrells 2015: 163). This seeks to address the relationship between planning and design within a planning paradigm that has historically treated design either as a shallow veneer or something much more comprehensive in its social, economic, ecological impact, aesthetic influence and affect on people (Punter and Carmona 1996: 1–2). From this, it is clear there exists shared concern between UK and China about the relationship between design and the built environment.

In short, there is increased awareness in China of the detrimental effect of rapid growth and globalisation on the historic townscape heritage. 'Historic preservation, heritage conservation and urban regeneration are three different but interrelated practices that are increasingly being recognised as critical to the future of Chinese cities in the 21st century' (Xie and Heath 2018: 15). In such a scenario it stands to reason that there will be increased need to commemorate heritage through graphic forms of communication.

4 Research methods

In this section we introduce graphic design as a framework for analysing urban graphic heritage before providing examples in the UK and China.

4.1 A framework for analysing urban graphic heritage

As noted earlier, graphic design is one of the most well-known and established design disciplines within the creative industries, even though it was relatively unacknowledged in the formation of the so-called cultural industries. It is more fundamental to design than most recognise. For example, at the beginning of the twenty-first century, graphic design was recognised as one of four orders in design, which is said to span symbols (graphic design), things (industrial design), action (interaction design) and thought (environmental design) (Buchanan 2001: 3–23). Hence, the symbolic preoccupation of graphic design provides a space for rethinking and reconceiving the idea of design for heritage. This is more so

because the recognition that ‘symbolism’ is implicit in planning concerns in historic environments, especially in relation to conflicts between preserving the past and changing societal values (Nasser 2003: 467–8), suggesting that an ‘orderly’ approach to graphic design can provide new perspectives on urban heritage.

For the purpose of this research an understanding of graphic design is drawn from two sources. First, we draw from very recent research into graphic design as a creative industries practice, which determines that practitioners display competencies in brand visual identity, digital design, film and animation, packaging and point of sale, print and advertising, retail and environmental design (Dziobczenski and Person 2017). In support of this is a consistency of typography, illustration and photography, which has underpinned various attempts to define the field since the early 1990s (Dziobczenski and Person 2017; Livingston and Livingston 1992; van der Waarde 2009). Furthermore, the idea of ‘graphic images’, meaning ‘pictures, statues and designs’ (Mitchell 1986) provides an easy interpretation. All three are relevant here, with particular emphasis on design. Such so-called images often define public places and urban spaces.

4.2 Graphic design for urban heritage

The relationship between graphic design and urban environment is not new. In the built environment there is an established tradition of graphic design being used to enhance ideas about urban heritage, reinforce local identity and convey meaning about places and spaces. The need for distinctive cultural or historical signifiers is commonplace in urban environments, and linked to internationally recognised standards. For example, the use of the colour brown to imply heritage and leisure is universally understood. Other examples of graphic objects are well known and immediately speak to heritage, such as the familiar blue heritage plaques that celebrate the London’s famous residents. Some graphic solutions are part of wider systems that are also localised, such as the City of Westminster street nameplate that signifies London’s theatre district within a territorial system that distinguished the city from adjoining boroughs in London. These are some of London’s well-known heritage signifiers. In rare cases, a graphic object may become the heritage. For example, the Abbey Road pedestrian crossing in London, infamous as The Beatles’ album of the same name: it qualifies as heritage because it is a government protected monument due to the cultural significance of The Beatles and their music. Further afield, regional cities are beginning to emphasize cultural themes to enhance their heritage credentials and attractiveness to visitors, such as Blackpool’s Comedy Carpet, an award winning celebration of the town’s comedic past. And many football teams now pay increasing attention to their past success, utilising heritage as an integrated part of stadium design. See Figure 3. This varied portrayal provides an indication of how graphic communication both commemorates heritage as well as being heritage.

Figure 3. A miscellaneous array of urban graphic objects. (Source: Author).

Shanghai is increasingly recognising the importance of architectural preservation by acknowledging iconic buildings through the display of commemorative wall plaques, its influential people through numerous statues, and displays internationally recognised signs that denote historical locations, as well as distinctive street furniture. See Figure 4. However, a significant difference in the portrayal of urban heritage between west and the east is that Shanghai heritage is written in two languages. This will not be discussed here, but will be a topic for future research.

Figure 4. A miscellaneous array of urban graphic objects in Shanghai. (Source: Author).

5 Research Contribution

It has been emphasised above that graphic design is an established and proven creative industries practice. Rapid urban development in China presents new opportunities to develop an integrative approach across the system of graphic communications that signify the visitor experience of urban heritage, in the twenty-first century, for what has been referred to as the ‘experience economy’ (Lupton 2017: 64–69). Graphic design is also an ‘architectonic’ practice (Buchanan 1989), well suited to the characteristics of the built environment professions of architecture, landscape architecture, city planning and civil engineering. We emphasise this aligned to what has been called the ‘graphic treatment of the cityscape’ (Julier 2014) through the various graphic objects that shape our understanding

of urban heritage. New knowledge and understanding about the products of graphic design in relation to design for urban heritage will help to establish the scope and scale at which urban graphic heritage impacts on townscapes in China and the UK. Thus, graphic design provides a unique overarching perspective for the design challenges associated with the human experience of urban heritage. Research about how graphic images complement the concept of urban heritage provides new perspectives and original insights into analyzing the ways graphic design interacts with urban design for the benefit of urban heritage, providing an answer to the question: What new perspectives can graphic design contribute to design for heritage?

6 Conclusion

The products of graphic design are relatively inexpensive by comparison to the products of built environment professions such as architecture, landscape architecture, city planning or civil engineering. However, graphic design provides significant potential for addressing the heritage concerns associated with urban development and regeneration in China. 'As cities in China strive to be competitive and attractive on the world stage, their decaying historical urban fabrics are being transformed into vibrant places through historical-cultural-led urban regeneration, however, the impact of their rapid development has escaped serious scrutiny' (Xie and Heath 2018). Social regeneration, technological innovation, and resource integration is a driving force for change in China, and is highly supported by the Chinese government. The synergy of industry, academia and research, and integration of resources from these different contexts provides a framework for urban development, and heritage is one sector that stands to benefit.

This paper has introduced how graphic design provides a distinct perspective on design for urban heritage. The research addresses the interests of a variety of fields engaged with the future of global cities, and the methods for understanding their complexity. This includes, but is not limited to architecture, landscape architecture, city planning, civil engineering, urban studies, history of art, architecture and design, design studies, urban geography, graphic design and the creative industries. Specifically, research into the role of graphic design for urban heritage is intended to benefit academics and practitioners working in graphic design, urban design and heritage, for the benefit of both the UK and China.

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Design Innovation Dimensions and Bottom of the Pyramid Market Principles: A Study to bring these together for an Approach to address Quality of Living

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The aim of the emerging stream on 'Design Innovation' (DI) is to harness human creativity for accomplishing outcomes, which are essentially of value. Accordingly, the scope of DI extends beyond aesthetics and styling towards innovation and value creation. On the other hand, addressing societal well-being and standard of living has in its scope 'Bottom of the Pyramid' (BOP) market segment that consists of a majority of the world's population. The characteristics of BOP market, with its unique principles, poses enormous challenges for the designer community, as they address this particular segment. The hypothesis in this paper is that mapping BOP market principles to DI dimensions can provide valuable guidance for the designer to arrive at solutions with worthwhile business proposition. A review-based research on both DI and BOP gave rise to the approach described in this paper. A study on the intersecting dimensions of DI and the pairing of these dimensions offers the necessary handle to address the unique nature of BOP market. Further to it, the participative approach of DI will add to the success of the endeavour wherein the BOP beneficiary would actively take part in the whole process.

Keywords: Design Innovation; BOP; Bottom of the Pyramid

1 Introduction

The context in this paper is about Design Innovation (DI) to particularly address Bottom of the Pyramid (BOP) population (Prahalad, 2004), as otherwise DI has largely been applied to the affluent segment of the society. The method of approach is discussed in this paper by leveraging DI, supported by field study validation. Accordingly, the basis of DI dimensions and their intersecting spaces are studied in search of an approach that comes closer to addressing the BOP market. There is certain perceived similarity between DI dimensions and BOP principles. This study is about if these two can be brought together in order to deal with quality and standard of living of people. Primarily it is a review-based study backed up by field study in a government hospital catering to BOP population.

The DI dimensions put forth by Tim (Brown, 2008) has been made use of, for the context in which design is to be undertaken. Both the Stanford Design School (Hasso Plattner Institute) and IDEO Design Firm subscribe to these dimensions with regard to DI. Field study findings at the actual site (physical premises of a Government Hospital in India), wherein the BOP population is being administered the necessary medical aid, is included as an illustration in support of the proposed approach.

Taking clue from the currently prevailing scenario all over the world, though several attempts have been made to address BOP segment, the results so far are not significant with respect to uplifting and improving the quality of life of the population in this segment. This is because the context of BOP is equally challenging and hence it requires a lot more creative and innovative ability on the part of the designer community to address it. This is where DI with its varied dimensional spaces can offer a handle to address BOP, which is riddled with business models, as well as business offerings and business execution challenges.

This paper begins by describing DI and BOP with due reference citation from the respective sources. Thereby it starts with a sound understanding about DI and BOP to position these together towards further usage for a possible approach. Later the discussion included in this paper describes the contribution for an approach in terms of how to leverage DI for BOP. To this extent, the narration in this paper talks about the resulting combined perspective between DI and BOP. Accordingly, the intersecting dimensions of DI leading to various business elements and their match with the unique nature of BOP are clearly detailed. Further to it, a mapping table between DI dimensions and BOP principles is captured to arrive at respective detail. An illustration from healthcare context aimed at BOP segment is included. Detailing possibility with the aid of standard design phases is described. It concludes by referring to the participative and empathetic approach in DI, which can further strengthen the line of thought in this paper.

2 Design Innovation (DI) – Review Study Brief

With innovation referring to new ways of value creation, combining innovation with design has the most promising effect in terms of harnessing human creativity towards accomplishing outcomes that are essentially of value. Accordingly, the emerging stream on DI is aiding to make the design interrogation scope complete, to address a given human endeavour.

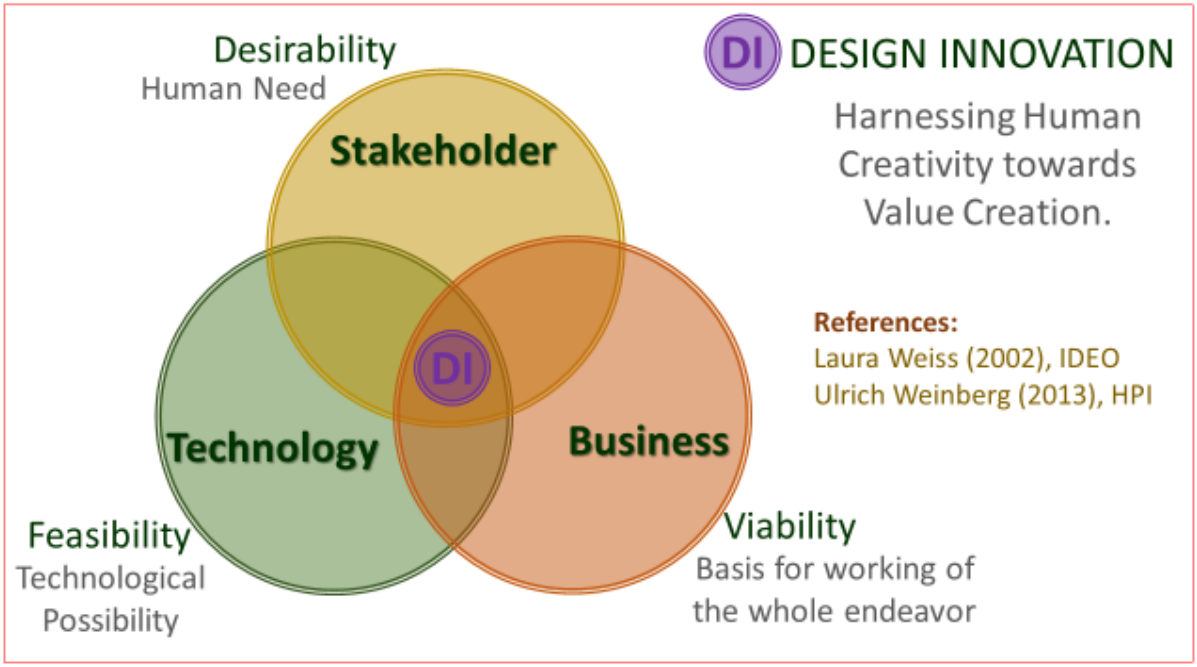

Figure 1: Design Innovation Dimensions from existing literature

As per Tim Brown of IDEO (Brown, 2008) and Ulrich of HPI Design School (Weinberg, 2013), DI is about addressing human desirability with what is technologically feasible and economically viable as a business. Ryong (Woo, 2007) from Seoul University refers to DI as a holistic approach to develop solutions. Vijay (Kumar, 2009) of Illinois puts forth a process for DI in the form of a series of steps. The authors Mutlu and Alpay (Mutlu & Alpay, 2003) narrates a historical and theoretical perspective on DI.

Innovation by definition (Baregheh et al, 2009) aims at 'value creation' and Design as the means can contribute towards realizing this aim. With reference to DI (as shown in Fig. 1), it has three dimensions namely desirability, feasibility, and viability. Addressing each of these and their paired intersections, would give rise to the corresponding focused outcomes that have a specific bearing on the whole gamut of value creation. With this line of thought, DI as a formal basis lends a handle that is complete in accomplishing a human endeavour.

2.1 Design Spaces resulting from the Intersecting Dimensions of DI

The three dimensions of DI and their intersecting spaces are further studied in search of an approach (for addressing BOP) as shown in Fig. 2. Overall, what is proposed through this study is that, each of these spaces can aid in sharpening and intensifying our focus towards the corresponding business elements that are detailed in the following sub-sections. Thereby it enables harnessing human creativity towards accomplishing meaningful ends, in a focused manner.

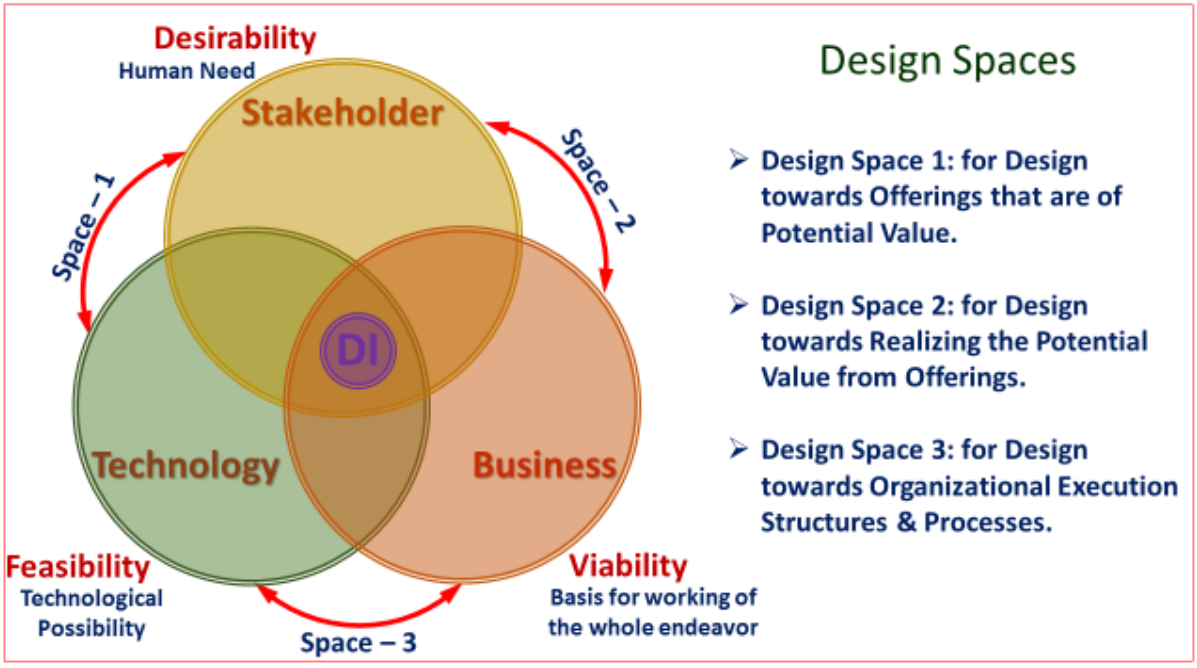

Figure 2: Design Innovation Dimensions and Intersecting Spaces

2.2 Design Space 1: Between Human Desirability & Technological Feasibility

Between desirability & feasibility, there lies the product or service offering that would supposedly fulfil a given human need. Accordingly, commensurate technologies are put to use in order to meet the given need. To this extent, design practice is applied to conceive and develop an offering that can potentially satisfy the given need. While in this intersecting space, what is proposed is that by leveraging the available technologies, one can address the various needs of the people through design. To this extent, design thinking is applied to come up with suitable Business Offerings.

2.3 Design Space 2: Between Human Desirability & Business Viability

Between desirability & viability, there lies the necessity to make the already conceived product or service offering appeal to people and create value for the stakeholder. Business Model being the rationale behind creation of value (Osterwalder, 2011), it points at such a goal with its associated elements inclusive of value proposition, customer relationship, etc. On the other hand, Viability as per Systems literature by Stafford Beer (Beer, 1992) is the ability to assert identity and accordingly the business firm should be able to assert itself while providing the offering, in order to be viable. This would amount to profitability and being able to sustain the business growth rate as per the expectations of the various stakeholders. To this extent, design practice is applied to come up with appropriate Business Models.

2.4 Design Space 3: Between Business Viability & Technological Feasibility

Between feasibility & viability, there lies the space within which the business would leverage technology as possible means in its endeavour to provide the offering as well as assert itself towards sustenance during business execution. As such, technology is leveraged to not only make the offering but to provide the offering in accordance with the stakeholder concerns. Thus, practicing design while in this space can lend a handle towards sharpening our focus, to come up with business execution mechanisms in the form of commensurate structure & process, which can enable the business endeavour towards successful outcomes. To this extent, design practice is applied while in this space.

The combined intersection between all these design spaces 1, 2, and 3, gives rise to the central and core space wherein innovation resides. Overall, the entire description on DI narrated as above, positions DI to be having huge potential in addressing various needs, be it business or societal or the combination of both.

3 Bottom of the Pyramid (BOP) Population Segment – Review Study Brief

Typically BOP / BPL (Below Poverty Line) Segment Population is characterized by very large number of people, whose purchasing power is quite small compared to that of the affluent population. The BPL segment has quite a few unique characteristics such as living on bare minimum earnings or wages, lower standards of quality of life, minimal literacy, large number of children, etc. Accordingly, the necessity to understand this particular population segment turns critical in order for the designer to address their specific needs.

Design as a practice is applicable irrespective of the segment population that it has been aiming at. Targeting BOP / BPL segment population would give rise to certain specific requirements in terms of lower affordability or purchasing power, lesser availability of resources, insufficient infrastructure facilities leading to marginal accessibility, etc. in addition to the large number of people it has. Accordingly undertaking design for BOP customer segment is equally challenging.

The authors Rosenbaum et al. (Rosenbaum, 2011) have conceptualized a research paradigm that centres on improving well-being of individuals and communities. Accordingly, they have put forth a research agenda that was further detailed out subsequently by authors Anderson et al. (Anderson, 2013) during the subsequent years. Overall, they have referred to a new area of research that can contribute towards understanding and minimizing the challenges facing current society, especially the BOP population segment.

In their editorial, Anderson et al. (Anderson, 2015) talked about a theme ‘Co-Creation and Well-Being’ wherein it referred to the context of BOP which constitutes about 2/3rds of the world’s population that live on less than 9$ (USD) per day and call for additional focus by

researchers. Raymond Fisk, et al (Fisk, 2016) in their call to action describes the need for understanding and reducing poverty. They talk about service design research as an approach to improve well-being in BOP as it focuses on devising courses of action for changing existing situations into preferred futures.

Ben Lataifa and Reynoso (Lataifa & Reynoso, 2014) in their paper on research and implications for BOP talk about value co-creation in BOP context. Prabhu Kandachar and Minna Halme (Kandachar & Halme, 2007) in their paper present a BOP Innovation Model consisting of User innovations, Technological innovations, and Business innovations.

The report from UN (Christine & Alban, 2008) talks about BOP approaches and urban sustainability. This report by UN Working Group primarily derives their basis from the book on BOP (Prahalad, 2004). The nature of the concept in BOP affirms that businesses can gain competitive advantage by targeting the poor at the bottom of the economic pyramid. By expanding the global markets to include BOP segment population would have the result of direct benefits to the poorer communities as well as providing business opportunity to corporate firms. Currently, the BOP segment is inefficient and uncompetitive. This is the primary reason why BOP population is facing enormous challenges with regard to their standard of living. Keeping this in view, inclusive and societal businesses are gaining momentum during the current times.

4 BOP Market Principles – Reproduced from BOP Literature Study

As per CK Prahalad (Prahalad, 2004), the BOP concept is built around three core principles which are Availability, Affordability, and Accessibility.

- Principle of Availability refers to prevalence of offerings required by the consumer.
- Principle of Accessibility addresses the key area of products / services distribution.
- Principle of Affordability is essential as it addresses gross economic power of BOP.

The BOP approaches, view the population segment as value conscious consumers and innovative entrepreneurs. Thereby it allows profit incentive for the business firms as they make the product / service offerings Available, Affordable, and Accessible to BOP market.

5 Combined Perspective between BOP Principles and DI Design Spaces

The dimensions of DI namely desirability, feasibility, and viability vis-à-vis the principles of BOP namely availability, affordability, and accessibility, has certain similarity to address BOP. Further study on the intersecting dimensions of DI offers a handle towards addressing BOP segment in accordance with its market principles. The intersecting spaces between these dimensions are especially of interest as they lend a handle for possible design outcomes.

Since DI is equipped to address the overall concerns of value creation, including that of BOP context, the combined perspective between BOP Principles and DI Design Spaces can offer a handle for an approach to address BOP market (as shown in figure 3).

5.1 Availability Principle and Design Space 1 (between Desirability & Feasibility)

As per the earlier description as part of DI, between desirability & feasibility, there lies the product or service offering that would supposedly fulfil a human need. Accordingly, commensurate choice of technologies are used in producing the offerings aimed at BOP segment. This would mean choice of technologies that could be advanced in nature, in order

to fulfil BOP segment needs. Accordingly, design practice is applied in this space and the Business Offerings are made Available to BOP population.

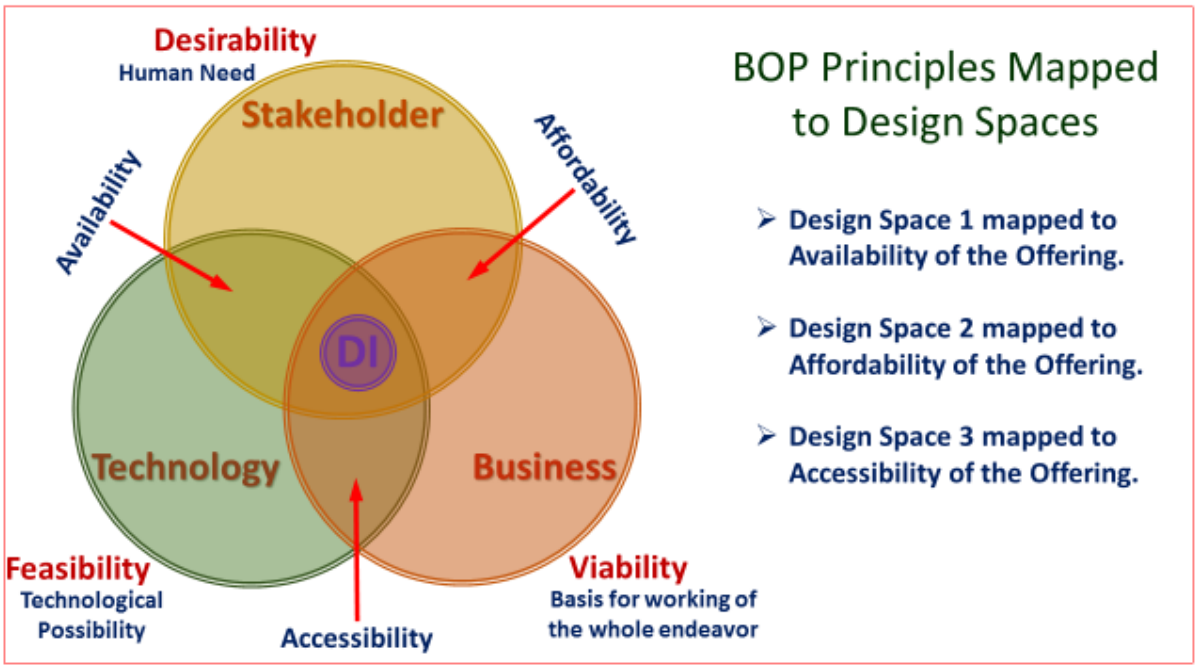

Fig. 3: BOP Market Principles mapped to Design Spaces

5.2 Affordability Principle and Design Space 2 (between Desirability & Viability)

As per the earlier description as part of DI, between desirability & viability there lies the necessity to make the already conceived product or service offering attractive to people in terms of price and affordability. To this extent, the various elements of the Business Model are detailed to enable meeting the BOP requirement. This would involve, compelling value proposition and customer relationship that is mutually rewarding to both consumer as well as the business firm. Often it could mean raising the earning capacity of the BOP consumer by way of suitable purchasing schemes. In addition, bringing-in several intermediaries into this context is an option worth consideration to reduce the price of offerings. Accordingly, design practice is applied in this space to come up with novel and innovative Business Models and the Business Offerings are made Affordable to BOP population.

5.3 Accessibility Principle and Design Space 3 (between Viability & Feasibility)

As per the earlier description as part of DI, between feasibility & viability there lies the space within which the Business is expected to leverage the technology as possible means towards making the offerings accessible to BOP population. It would amount to conceiving and developing mechanisms by which business execution is possible. The various execution mechanisms would involve commensurate structures and associated processes. Often the mechanisms could be in the form of distribution channels for products and services. To this extent, design practice is applied while in this space and the Business Offerings are made Accessible to BOP population.

Overall, the proposed approach can aid in orienting the thought process of the designer towards addressing BOP market. The approach lies in focusing, in adherence with the BOP principles, and leveraging the design spaces offered by the corresponding intersecting dimensions of DI, towards a meaningful design endeavour aimed at BOP market.

Accordingly, the proposed approach benefits from the mapping between BOP and DI. The DI dimensions being complete with respect to creation and capture of value, it lends a handle to the designer in a systematic manner to address BOP market. Further to it, applying the standard design phases will strengthen the whole design endeavour.

6 Approach by Mapping between BOP Principles and DI Design Spaces

The resulting approach by way of the combined perspective between DI and BOP enables the designer to establish a direct mapping towards addressing the unique characteristics of BOP market. The main guidance portion in this approach is to undertake design within the respective intersecting spaces, with an aim towards designing corresponding business elements, in adherence with BOP principles. To this extent, the proposed approach is promising, as it has been attempted in the field study illustration of providing Healthcare offerings in a Government Hospital, catering to BOP segment population. Similar attempts in other cases with regard to various offerings aimed at BOP can strengthen this approach further.

Table 1: Intersecting Dimensions of DI vis-à-vis BOP Principles, with indicative detailing (generic)

BOP Market Principles	***Intersecting Dimensions of DI***		
	Desirability & Feasibility	*Desirability & Viability*	*Viability & Feasibility*
Availability	Possibility to meet the BOP need by leveraging choice of technology. Accordingly conceiving and developing a Business Offering.	Value proposition that is commensurate with the population segment need.	Customer Relationship, and Channel Execution, while providing the Offering.
Affordability	Choice of technology to make the Offering affordable. Scale and Volumes are part of this scope.	Making the offering attractive and appeal to BOP segment by way of price and profitability for the provider firm.	Raising the purchasing ability and earning capacity of BOP population, while providing the Offering.
Accessibility	Choice of technology to make the Offering accessible. Packaging possibility and the corresponding designs for the Offering.	Design of Channels in order to meet the distribution challenges. Execution of the whole Business endeavour by means of required structure & process.	Design of execution structure & process for realizing business, primarily with respect to making the offerings accessible to BOP, by leveraging technology.

A generic mapping between intersecting spaces of DI vis-à-vis the principles of BOP is briefly detailed in Table 1. This can amount to design of the entire supporting ecosystem.

7 Field Study illustration on Healthcare Offerings for BOP Segment

A field study illustration from Healthcare aimed at BOP segment population in India has been included in support of the proposed approach. The government run hospitals in India cater to the healthcare needs of BOP population. A study undertaken at one of these hospitals in its Casualty Out-Patient (Emergency Medical Aid) department, over a period of 12 weeks, has pointed to a perceived need in the form of inexpensive and disposable ‘sanitary bed sheets’. This specific case is briefly detailed in Table 2.

Often a government hospital facility in rural India is inadequate in terms of availability of stretchers, beds, etc. especially if many victims / patients turn up at the same time or in a lesser time window. It is observed that during usage, the stretchers have blood strains on them and these are not being cleaned-up but used repeatedly by other patients for lack of time and facility infrastructure. Lack of sufficient infrastructure at these government hospitals has been resulting in re-use of stretchers and beds for patients without proper cleaning / sterilization, as the victims arrive in large numbers for want of emergency medical aid. Making the 'sanitary bed sheets' available at these hospitals can improve this situation, but these bed sheets need to be inexpensive and should cost only about 10 cents each. To run the hospital at this 'economies of scale' requires the whole gamut of Design Innovation to be undertaken in order to make the 'sanitary bed sheets' available, affordable, and accessible.

Table 2: Field Study Illustration – 'Sanitary Bed Sheets' for BOP population (specific case)

BOP Principles	***Intersecting Dimensions of DI***		
	Desirability & Feasibility	*Desirability & Viability*	*Viability & Feasibility*
Availability	Possibility to meet the BOP need by leveraging choice of technology in order to make bed sheets. It is likely that bed sheets of such specific necessity are yet to be developed.	Value proposition by way of enhanced quality of medical care and quality of living standard that is available at a nominal price.	Relationship with Patients and Attendants, while providing 'sanitary bed sheets' as per the need. The bed sheets should be of disposable type.
Affordability	Choice of technology to make it affordable. Scale and Volumes are part of this exercise. The bed sheets should be inexpensive and should not cost more than a few cents (5 to 10 cents only).	Making the bed sheets attractive and appeal to BOP population by way of price and profitability. They should be extremely inexpensive at the same time viable for the Providers.	Customer Relationship and facilitating the purchase by BOP population, while providing the 'sanitary bed sheets'.
Accessibility	Choice of technology to make the bed sheets quite accessible. Packaging possibility and the associated designs. Design of Channels in order to meet the distribution challenges.	The bed sheets should be stacked right at the entrance of the Emergency Medical Aid Department and the victim's attendant should be able to get it very easily, both by way of numbers and price.	Execution of business, primarily with respect to distribution channels, to make the bed sheets accessible to population by way of appropriate structure and process.

The mapping between intersecting spaces of DI vis-à-vis the principles of BOP for the case of 'sanitary bed sheets' is briefly described in Table 2. Providing for sufficient infrastructure facility would require detailed design innovation in terms of affordability, availability, and accessibility of 'sanitary bed sheets'. Since the Bed Sheets need to be inexpensive at a nominal price of about 5 to 10 cents each, several intermediaries are to be brought into context to lower its price. However, at the same time, the vendors can make up for it only when the Bed Sheets are sold in large volumes. To this extent, the supply and distribution ought to happen all across the state run hospitals to add up for volumes.

Ideally, the Bed Sheets should be made available right at the entrance / main door of the hospital wherein the casualty victim is brought into the premises. The design should cater to this entire 'channel' ecosystem, keeping in view of the price and access. Accordingly, it exposes the designer to corresponding additional concerns that are critical to address.

8 Detailing possibility by applying the Standard Six Design Phases

Having been able to focus on the respective BOP principles, the detailed design exercise can be undertaken in adherence with the standard design phases. This is captured in Tables 3 to 5 in an indicative manner for each of the BOP principles namely Availability, Affordability, and Accessibility.

9 Summary and Conclusion

What we have proposed in this paper is that, by leveraging Design Innovation, an approach has been put forth for addressing BOP market segment. The relevance and match between BOP market principles (Availability, Affordability, and Accessibility) and DI dimensions (Desirability, Feasibility, and Viability) is evident from their respective descriptions. Further to it, the intersection between DI dimensions has given rise to formal design spaces in order to focus and address the BOP market. The main contribution in this paper is the manner in which DI dimensions and BOP principles are brought together for an approach.

Though the intersecting spaces between DI dimensions would give rise to design of business offerings, business models, and business execution structure & process, this inference has not been stated deliberately for want of further research evidence. Accordingly, these business elements can be directly mapped to DI dimensions as well as BOP principles.

The above study describes a perspective that is centred on DI, which directly maps to the Principles of BOP. On the other hand, the central core intersection of DI imposes the necessary and appropriate constraints on all the three adjacent intersecting dimensions, thereby making the whole endeavour cohesive and complete. This manner of working aids in enhanced focus and attention with respect to addressing BOP segment. Thereby practicing design in each of the intersecting spaces of DI makes it a lot more effective and meaningful.

This approach can be further substantiated with suitable illustrations and additional case studies from Government run hospitals in India providing medical care and retail businesses in rural parts of India fulfilling a large portion of the domestic needs of BOP population.

Further to it, the participative approach in DI can add to the endeavour by way of collaborative innovation. With BOP strategies aiming at improving the purchasing power of the population, the participative approach can make such an aim possible. In addition, the empathetic approach in DI would make sure that the endeavour would succeed. These two characteristics in DI, namely empathetic and participative / collaborative approaches, offer a huge advantage when it comes to dealing with BOP segment. These are covered in the current scope of this paper in an indirect manner by virtue of the approach.

Scale is an important aspect when dealing with BOP segment. The required economies of scale by way of volumes of production as well as distribution ought to be addressed in DI scope. This aspect is indirectly covered in the current scope of this paper.

Overall DI has a huge potential for Designer Community to make a difference to the BOP population by way of up lifting their standard of living and improving their quality of life.

*Table 3: Field Study – Government Hospital – Casualty Out-Patient (COP) Department – **Availability** - Detailing possibility as per Standard Design Phases*

Design Phases	***Understand***	***Observe***	***Point of View***	***Ideate***	***Prototype***	***Test***
***Availability** of Business Offering*	*Situation.*	*The Lack.*	*Facility Need.*	*Sanitary Bed Sheets*	*Disposable and Affordable Bed Sheets*	*To be Accessible at COP Entrance*
Victims / Patients arriving in the Casualty Out-Patient (COP) Department of the Hospital premises for emergency medical aid. These hospitals are located in rural parts of India.	Generally, these are Road Accident Victims with broken limbs, head injuries, etc. One can see that they are bleeding all over their body. Often they are shifted to hospital by 3rd party who happen to notice them lying on the roadside. Their relatives come along rushing, once they are informed about it. Generally, they come in large numbers to the hospital. With every one having a phone these days, most of them will be talking over the phone and informing the status to others.	Often the facility infrastructure in general hospital in rural India is barely adequate for the demand it ought to support. The stretchers and beds, on to which the victims will be shifted to from the Ambulance vehicle, are not cleaned-up well. Having come to the hospital, people expect that things will soon get better. They are all poor people.	The BOP population seem to be indifferent for the cleanliness and hygiene in the hospital premises. If certain sanitary bed sheets are made available and accessible to them at nominal price of a few cents, they might opt to buy one. In case it is still not affordable for them, a 3rd party NGO (not for profit organization) may come forward to bear its cost and make it accessible for them. To this extent, the design innovation requires to address it.	The bed sheets are to be of disposable type. If possible, the bed sheets should be able to carry the weight of a patient. That way the bed sheet can be used instead of a stretcher.	Supply and Distribution channels are to be conceived, designed and put in place. Many of the vendors may already have these bed sheets available in their stores but the price could be unaffordable.	The Bed Sheets are to be stacked near to the COP entrance and be available to the victims / patient attendant who are in need.

*Table 4: Field Study – Government Hospital – Casualty Out-Patient (COP) Department – **Affordability** – Detailing possibility as per Standard Design Phases*

Design Phases	***Understand***	***Observe***	***Point of View***	***Ideate***	***Prototype***	***Test***
***Affordability** of Business Offering*	*Situation.*	*The Poverty.*	*Facility Need.*	*Sanitary Bed Sheets*	*Disposable and Affordable Bed Sheets*	*To be Accessible at COP Entrance*
Victims / Patients arriving in the Casualty Out-Patient (COP) Department of the Hospital premises for emergency medical aid. These hospitals are located in rural parts of India.	Generally, these are Road Accident Victims with broken limbs, head injuries, etc. One can see that they will be bleeding all over their body. Often they are shifted to hospital by 3rd party who happen to notice them lying on the roadside. Their relatives come along rushing, once they are informed about it. Generally, they come in large numbers to the hospital.	Often the facility infrastructure in general hospital in rural India is barely adequate for the demand it supports. The stretchers and beds, on to which the victims will be shifted to from the Ambulance vehicle, are not cleaned-up well. Generally, the BOP population are poor and cannot afford much. They end up staying in the hospital premises, with a bed if available, for the patient victim.	If certain sanitary bed sheets are made available and accessible to them at nominal price of a few cents, they might opt to buy one. In case it is still not affordable for them, an intermediary may come forward to bear its cost and make it accessible for them. To this extent, the design innovation requires to address the whole ecosystem.	The bed sheets are to be of low cost. The whole ecosystem need to be addressed to bring down the price of bed sheet to a few cents. If it is not affordable by them, another intermediary should come in and augment the need.	The logistics and several levels of intermediaries to bring down the cost and volumes to be addressed. Quite likely, the challenge is in terms of price as production of bed sheets is generally not an issue. It should cost only a few cents, about 5 to 10 cents, but not more than that.	The Bed Sheets are to be stacked near to the COP entrance and be available to the victims / patient attendant who are in need. The patient attendant often may not have any money to pay.

*Table 5: Field Study – Government Hospital – Casualty Out-Patient (COP) Department – **Accessibility** – Detailing Possibility as per Standard Design Phases*

Design Phases	***Understand***	***Observe***	***Point of View***	***Ideate***	***Prototype***	***Test***
***Accessibility** of Business Offering*	*Situation.*	*The Possibility.*	*Facility Need.*	*Sanitary Bed Sheets*	*Disposable and Affordable Bed Sheets*	*To be Accessible at COP Entrance*
Victims / Patients arriving in the Casualty Out-Patient (COP) Department of the Hospital premises for emergency medical aid. These hospitals are located in rural parts of India.	Generally, these are Road Accident Victims with broken limbs, head injuries, etc. One can see that they will be bleeding all over their body. Often they are shifted to hospital by 3rd party who happen to notice them lying on the roadside. Their relatives come along rushing, once they are informed about it. Generally, they come in large numbers to the hospital.	Having come to the hospital, they expect that things will soon get better. Generally, they are poor and cannot afford much. If design and innovation can address their need, it would help them greatly in improving their standard and quality of living.	If certain sanitary bed sheets are made available and accessible to them at nominal price of a few cents, they might opt to buy one. Immediate access to medical doctor is paramount. What matters to these people is whether a medical doctor has come and attended to the victim or not.	The Supply and Distribution should be taken care to meet the demand and the need. To this extent, the practice of design innovation requires to address the whole ecosystem. Other partnering vendors of the hospital can get involved with this need.	The logistics and several levels of intermediaries to bring down the cost and to increase volume to be addressed. Supply and Distribution channels to be put in place. Accordingly design innovation to address the whole chain.	The Bed Sheets are to be stacked near to the COP entrance and be available to the victims in need. If these are placed elsewhere away from COP Entrance, it may not help much. Usually the patient victim is unconscious and the patient attendant is in a shock. Therefore, these should be readily accessible without even asking.

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Designing for Improving Sleep Hygiene through the Reflection of Smartphone Awareness with Ambient Lighting

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Sleep is one of the most essential elements for our health. Nevertheless, overall sleep hygiene is going to decrease nowadays. One of the major reasons that worsens sleep hygiene is our smartphone use before sleep. Thus, this study aims to explore design opportunities for improving sleep hygiene by inducing people to reduce their smartphone use in an unobtrusive manner. To figure out habitual behaviors related with smartphone use before sleep, we have conducted a series of focus group interviews. The results indicated that participants tend to use their smartphone without being aware of the negative influence on sleep quality. Based on the findings, we developed apparatus with ambient lighting. We deployed and interviewed its uses through a field study with eight participants. To conclude, the ambient lighting notification could help them to be easily aware of their smartphone use patterns and reduce its usage time before sleep. The implications and further study are discussed as well.

Keywords: Sleep quality, sleep hygiene, smartphone, arousal, ambient lighting

1 Introduction

Researchers, academics and practitioners are invited to submit a paper for the IASDR Sleep has made a great impact on our lives as one of the most important factors in staying healthy. For good sleep, the quality of sleep is more important, rather than simply increasing the amount of sleep (Pilcher, Ginter, & Sadowsky, 1997). When the quality of sleep is poor, it causes the feelings of depression (Dijk & Czeisler, 1995), anxiety, fatigue, and confusion. In addition, it reduces the effectiveness of study and work in daily life (Wyatt, Cecco, Czeisler, & Dijk, 1999; Zeitzer, Dijk, Kronauer, Brown, & Czeisler, 2000) and negatively affects interpersonal relationships as well (Alvarez, Dahlitz, Vignau, & Parkes, 1992). Thus, having a good sleep is of importance for both physical and mental health.

The quality of sleep is dependent on how good or bad sleep behaviors were undertaken before sleep, which is defined as sleep hygiene. Good sleep can be achieved when sleep hygiene is sound: good sleep hygiene includes regular sleep schedules, avoiding thirsty or negative emotions before going to bed (Brown, Buboltz, & Soper, 2002), cutting down alcohol and caffeine intake (Bootzin & Perlis, 1992). Especially, university students have been reported to have poor sleep hygiene and they are known for serious sleep deprivation

(Brown et al., 2002; Medeiros, Mendes, Lima, & Araujo, 2001). A major cause of the sleep deprivation is a decrease of total sleep time resulting from late bedtime and irregular sleep-wake cycles (Lack, 1986). To make it worse, easy access to computers and mobile phones in bedrooms has been known for a major contributor of these sleep disturbances (Guo et al., 2017; Asaoka et al., 2010).

Several studies in the field of Human Computer Interaction also clarified the relationship between sleep outcome and digital media use. According to Kathryn et al.(Orzech, Grandner, Roane, & Carskadon, 2016) , the more time spent on digital media cause less total sleeping time and later bed time. And the more diversity in digital media activity causes earlier bedtime ending up with more sleep time. Especially, the use of smartphone makes a big impact on sleep quality (Anne-Marie, Daniel, Jeanne F, & Czeisler, 2015; Czeisler, 2013). Those who used their own smartphones often sleep and get up later, and also frequently wake after sleep onset, and end up with low quality of sleep than those who did not (Orzech et al., 2016; Brunborg et al., 2011).

A number of studies have been conducted to analyse the causes why smartphones affect sleep quality. Some studies first claimed it is due to light emitted from the device before sleep. Low-frequency-light emitted from smartphone reduces the secretion of the melatonin which is a sleep- inducing hormone (Goel, Abe, Braun, & Dinges, 2014), and maintains awareness that delays the hours going to sleep (Cajochen, Frey, Anders, Spaeti, & Bues, 2015). That leads people to experiencing low quality of sleep and poor wakefulness (Wyatt et al., 1999; Dijk & Czeisler, 1995;). Secondly, high cognitive work load with smartphones produces longer sleep onset latency (Galambos, Dalton, & Maggs, 2009). In addition, mental fatigue resulting from smartphone use leads to a reduction in goal-directed attention. This stimulates shifting their attention to irrelevant stimuli. Also, the mental fatigue leads them to go to bed early, but this does not mean that they are sleepy (Bokesem, Meijman, & Lorist, 2005). Thus, it is very obvious that the use of smartphones before sleep has had a strong negative impact on health and overall life. Surprisingly, the percentage of users who use their smartphone before sleep is approximately 72% among smartphone users (Dean, 2010). They are not aware of the harmfulness of using smartphone before sleep according to Dr. Mark Aloia, a senior researcher at Philips Global Clinical Laboratories. Nevertheless, previous studies have focused only on the relationship between digital media use and sleep quality (Philips, 2015). Little research has been conducted on exploring a way to make people aware of the harmless of smartphone use before sleep. Moreover, some existing solutions are focused on preventing smartphone addiction only in the form of fidgeting and other devices and apps. However, we regard user behaviors with smartphone before sleep as habitual activity rather than smartphone addiction in the study. Therefore, our study does not explore solutions for smartphone addiction prevention but attempts to explore ways as design opportunities to improve sleep hygiene of university students, who have experienced serious sleep deprivation, in terms of smartphone use by identifying the relationship between smartphone use and sleep disturbance. Li et al.(2010) proposed a five-level of personal informatics system that collected personal information and led to changes in behavior (Figure 1). The fourth step of 'reflection' is the reflection of the user, and the fifth step is 'acting' through stimulation for a longer period of time. The goal of this study is to explore the 'reflection' phase: that is, designing for the user to be aware of the relationship between smartphone usage and sleep hygiene before bedtime.

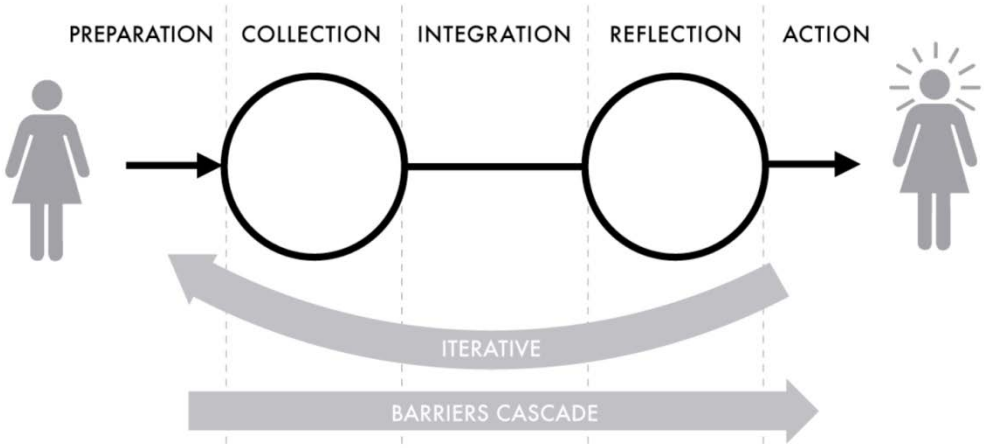

Figure 1. The Stage-Based Model of Personal Informatics Systems (Li et al., 2010)

In order to achieve the goal of the study, the following research questions were formulated:

- Why do university students use smartphone before sleep?
- What do university students do with smartphone before sleep?
- How would ambient lighting notification of usage affect the awareness of smartphone use before sleep?
- In which way could design encourage sleep hygiene through reducing the amount of smartphone use before sleep?

By answering the research questions, it is expected that a new way of interaction for awareness with smartphone before sleep could be discovered. It could also provide a new design opportunity with designers who aim to create a new interactive product/service for better sleep quality of not only university students but also general users.

2 Initial exploration and experiment

2.1 Experiment design

An experiment was designed with two methods in order to answer the research questions: what and why university students use smartphone before sleep, and what design solutions would be possible to reduce the amount of smartphone use for good sleep hygiene. First, a focus group interview was adopted to understand the smartphone use of university students before sleep. Secondly, based on the understanding of actual use with smartphone, design guidelines were derived. Two experimental prototypes were made according to the guidelines. Finally, a field experiment was carried out in order to compare and evaluate the effectiveness and experience of the experimental prototypes in a way to install the prototypes in the real sleep environment. Below is a briefly summarized figure of experimental design of the study (Figure 2). The experiment is conducted for 3 days rather than a continuous behavioral change because the focus of the study is on the reaction when users are aware of smartphone usage before sleep.

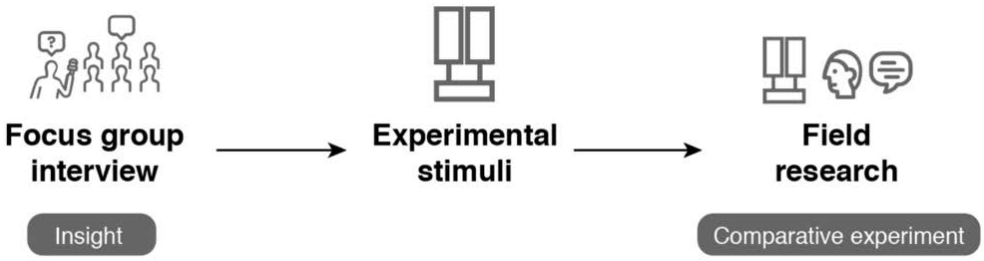

Figure 2. The research approach for the study

2.2 Focus group interview

To understand the actual use of smartphone before sleep and also figure out how people perceive the use of smartphone before sleep, a focus group interview was conducted with 10 university students (six males and four females). Their age ranged from 21 to 29 years old and their majors varied from human factors and chemistry to industrial design. They were recruited from the student community of the university among those who habitually used smartphone before their sleep almost on everyday bases.

2.2.1 Interview questions

In order to figure out what university students do with their smartphone before sleep and why they do so, four interview questions were formulated:

- How long usually does it take from lying down on the bed till falling asleep?
- What activities do you usually do with smartphone before you go to sleep?
- If you know the fact that smartphone use before sleep causes sleep disorder, would you still keep using the smartphone, nonetheless and why?
- Why do you have difficulties in stopping smartphone use before sleep?

2.2.2 Procedure

The participants were divided into two groups (five persons per group) based upon gender balance. Two sessions of focus group interview were conducted one after the other. The participants were invited to a resting place at the university to provide natural atmosphere (Figure 3). Before each session, participants were asked to complete a survey about their habitual patterns including pre-sleep activities, sleep time and purposes of using a smartphone before sleep. The purpose of the focus group interview was also introduced. A session took approximately 30 minutes. The interview was voice-recorded and transcribed. The data were qualitatively analysed by using an affinity-diagram method, with which answers to the interview questions were categorized in terms of similarity.

Figure 3. A session of the focus group interviews conducted in the study

2.2.3 Results

According to the results, particular applications of smartphone were frequently used before sleep (Table 1). Online video sharing services such as YouTube and Netflix were the most popular application (80%). Particularly, they kept watching videos even over night because of the associative video recommendation systems. While more than half of the participants played mobile games before sleep, four out of 10 participants played no mobile games at all because of worries of addictiveness that could inhibit their sleep. However, surprisingly, participants suppressed use of smartphones in some cases. Three of the participants answered that mobile games before going to bed induces disturbed sleep, and that made them do not play the mobile game before sleep. This was followed by music and social media such as Kakao talk and Facebook. Awareness of smartphones affecting sleep is not understood by many, and few understand why. In addition, three of 10 participants thought that sleep tracking applications letting them recognize sleep time and sleep quality would be convenient and helpful, but such applications were hardly used.

For the question asking what makes them stop using smartphone before sleep, half of the participants answered they had stopped because they felt sleepy (Table 1). Three of them also mentioned that next day's schedule or perception of lack of sleep time had made them stop using the smartphone. Moreover, a female participant stopped using her smartphone due to weariness: she stopped until she saw the same post in Facebook again that had already seen in the morning. All of the participants already recognized the negative effect of smartphone use before sleep. Nevertheless, they did not stop using their smartphones because they hardly felt the difference in sleep quality when using smartphone or not: they were not aware of how sleep hygiene was influenced by the cases of using and not using smartphone before sleep. Because video streaming services keep recommending more related videos, it was also a reason of keeping using smartphone before sleep. They avoided games because they were aware of the addictive effect, but they were not aware of the addictiveness of recommendation systems. It was also interesting that some of them preferred a less disturbing way to stop using smartphone if it is possible.

Table 1 Frequencies analysis of result of the focus group interview

Question	Response	Frequency
Activities with smartphone before sleep	Video (YouTube)	5
	Games	4
	Music	2
	Social media	1
Causes of stop using the smartphone	Sleepy	5
	Pressure of time	3
	Weariness	1
	Visual stimuli	1
Causes of keep using smartphone despite they know that effect of using the smartphone before sleep	Can't feel it	8
	Addictive content	1
	Non-believer	1

2.3 Experimental stimuli

The features of experimental stimuli were derived from the results of the focus group interview. According to the results, it would be critical to make university students aware of usage time of their smartphone before sleep on one hand, and the impact on sleep on the other hand in order to help them stop using smartphone before sleep. Therefore, the way to

make them aware of both information needed to be considered in developing experimental stimuli. The information for visualization was 1) the sleep time set by the user, 2) a reminder that sleep time is approaching, and 3) the arousal level corresponding to the duration of smartphone use. It was necessary to confirm that these three visualizations could act as a motive to stop using their smartphone. To deliver the information, ambient light was chosen among the various means because light can deliver information without disturbing main task (smartphone use), which was also mentioned in the focus group interview. As Nam's research team described in (Nam, Park, Seok, & Kim, 2009), among the dynamic design elements of the ambient media, a combination of brightness change and speed of light is most effective for recognizing information. This was applied to our experimental prototypes. In this way, it was expected that the change of ambient mood light can function as a bed time reminder while users keep focusing on their smartphone. This system that control the sleep environment through ambient light seems similar to the Philips Hue wake-up light (Philips, 2010). And there are several examples of wake-up lamp in product design field. They are all products that help users to get better morning through the change of light color (Rjpereira, 2017; Delisse, 2015). D-TOX is a sleep lamp that by applying gamification to a smart lamp and mobile application reduces the frequency of smartphone usage during nighttime. It aimed to reduce smartphone usage during nighttime specifically to children (Lee, Lee, Kim, & Cho, 2017)(Figure 4). Other design examples were morning lights through a similar color of sunlight. Indicating information and controlling the sleep environment are a common point. However, there is a clear difference between their prototypes and our prototype. Existing cases including the Philips hue are focused on the ability to wake up user through sunset color. D-TOX attempted to reduce the usage of smartphones before sleeping, as the color of lighting changed through the mobile game system. However, our prototype is focused on the bed time reminder and indicating arousal level.

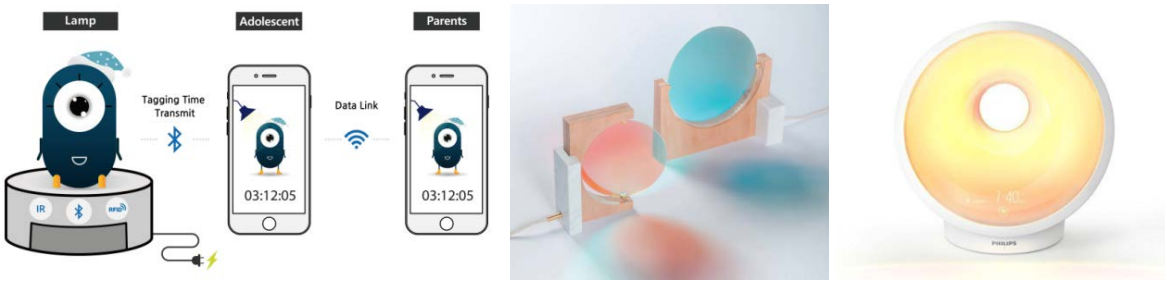

Figure 4. From the left, D-Tox(Lee et al., 2017)*, Day and Night lamp* (Delisse, 2015)*, Philips Somneo* (Philips, 2017)

2.3.1 The conceptualization of experimental stimuli

Prototype A functions like a bedtime reminder in the form of ambient mood light that tells the remaining time from the current time until bedtime. Prototype B is also a bedtime reminder, but it has significant difference with prototype A. On the left light of prototype B is same with prototype A. However, the right one is a light to inform the arousal level corresponding to the usage time of smartphone (Figure 5). In this way, it is expected that the user can be better aware of his/her arousal level with the use of smartphone.

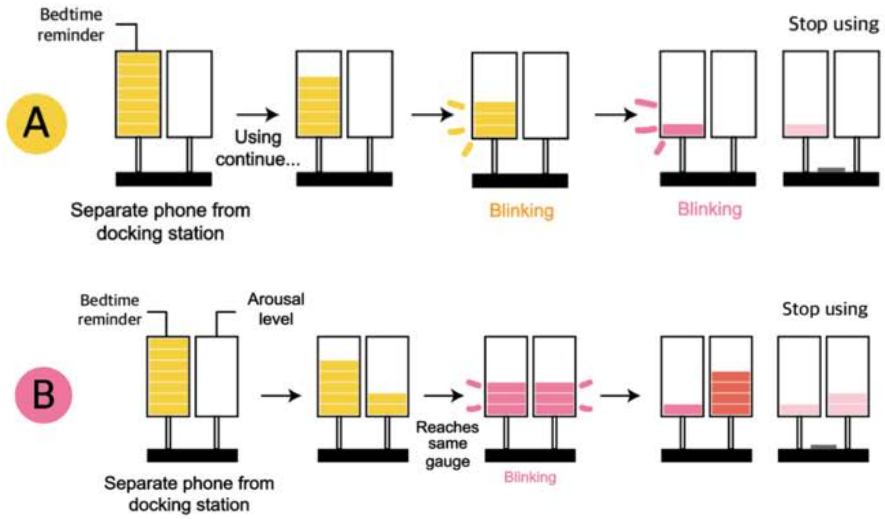

Figure 5. Working mechanism of experimental prototype A (Above) and B (Below)

2.3.2 Working mechanism (interaction)

Although there are a number of notification modality, we adopted a linear lighting expression because the lighting is one of most familiar sources of information transfer in our everyday life and could provide a clear cue of remaining time rather than abstract information. In both of prototype A and B, except for the first docking, when the mobile phone is disconnected from the station, all 10 pieces of light are turned on and the operation starts. The closer the bedtime set by the subject, the more gradually the lights turn off to notify the sleeping time is approaching (Figure 5).

Prototype A gradually dims as the bedtime approaches. When the smartphone is in the station, it means that it is not used, so the brightness of the light becomes dark. On the other hand, when the station is empty, it means that the user is using the smartphone, so the brightness is become brighter. The lighting is divided into 10 spaces and means the time remaining from the first time to use smartphone at the night of day to the bed time sleeping time. When there are three lights left, the light flickers to indicate that it is nearing the bedtime. If only one light left, it turns red and flashes to inform that it is almost closer to the time to go to bed. After that time, the light goes off.

In the meantime, prototype B's bedtime reminder (left light) is turned off as time goes by, like prototype A. However, the arousal level on the right starts with all off and turns on one by one in proportion to the use time of smartphone. When user put their smartphone on the station, the brightness of the light dims like A. At the moment that the gauge of both lights is the same, it blinks in purple representing the right time to sleep considering your high arousal level. If the user continues to use smartphone and reach an arousal level that is higher than the time remaining, the color of the light turns red.

2.3.3 Embodiment design

The final prototypes consist of two lights, a docking station, and a box with parts. Prototype A uses only the left one of two lights, and prototype B uses both lights. There are 10 LEDs inside each lampshade. The brightness and color of those LEDs are controlled by the mainboard Arduino Uno.

In order to find out the use time of smartphone and the time to sleep, we recorded both the starting point and the ending point of the smartphone use. To do this, we created a smartphone docking station between the two lights. We assume that if there is no smartphone on the station, it means 'start to use'. And if there is smartphone on the station, it means 'stop to use'. An infrared sensor was installed under the station to recognize the states. In addition, to record accurate usage time, whenever users start and stop using smartphone, the time is automatically stored in the SD card with RTC (real time clock) at the moment.

2.4 Field research

2.4.1 Participants

Eight undergraduate and graduate students (four males and four females; two undergraduate students, six graduate students,) whose ages ranged from 21 and 29 years old participated in the experiment. Similarly to the previous focus group, we recruited people who had known the effects of sleep on their smartphone but could not feel it. In addition, they were recruited among those who had their sleep room in a dark environment and used their smartphone more than an hour before going to bed on everyday bases at the time of the experiment.

2.4.2 Research questions for the study

In order to figure out usability and user experience with the experimental stimuli, the following questions were formulated:

- How does showing arousal level affect the usage time of smartphone?
- Which of the two experimental prototypes would be more affected on self-reflection through awareness?
- What kind of experience can be delivered to the participants with the ambient light notification?

2.4.3 Procedure

In order to derive user experience in actual context, the experimental prototypes were installed in the sleeping room of the participants (Figure 6). The experiment consisted of five stages. First, we looked at basic smartphone usage time and sleep time of users in a pre-interview. In addition, before the experiment participants were requested to refrain from things that could significantly affect their sleep quality such as drinking and doing overtime during the period of the experiment. After the pre-interview, it was asked for the participants to set prototype A first in a conspicuous place near the bedside of their sleeping room and then to use it for three days (Monday till Wednesday). Before beginning the experiment, we gave participants enough explanations about the experiment contents. We received a written consent from all participants. To make the experience as habitual as possible, participants were asked to place the prototype next to their bed during the whole period of the experiment. To do this, we provided a box for a bedside table to them. On the next day, an interview was carried out in which the usability and user experience with the prototype was asked. Four days of break was given in order to minimize the effect of prior experience (Thursday till Sunday). From next Monday, prototype B was again installed in the same place and also was asked to use the lamp for three consecutive days. On the next day, a retrospective interview was finally conducted mainly aiming to compare the user experience between prototype A and B.

Figure 6. Example of the prototypes installed in actual sleeping rooms of the participants

3 Results

From the experiment, a total 578 interactions of log data (putting the smartphone on the plate and lifting from the plate) were collected. To evaluate the related experiences with the two prototypes, we compared the following variables by analyzing the data from the experiment and interview. First, we compared how the two prototypes had been perceived in terms of smartphone usage time and time to sleep. Secondly, we compared the degree to which users were pressured to stop using smartphones and sleep from these two prototypes. Next, we also compare whether the awareness and pressure of the two prototypes led users to self-reflection through awareness related to smartphone use and time to sleep. Finally, the users' preferences between the two prototypes were measured.

3.1 Time during smartphone

Comparing the smartphone usage of the two prototypes, we found that the use of the smartphone was significantly reduced in prototype B (Figure 7). Among five participants the actual total use amount of smartphone was much more reduced when they use prototype B than prototype A. This implies that earlier time to sleep can be facilitated by prototype B.

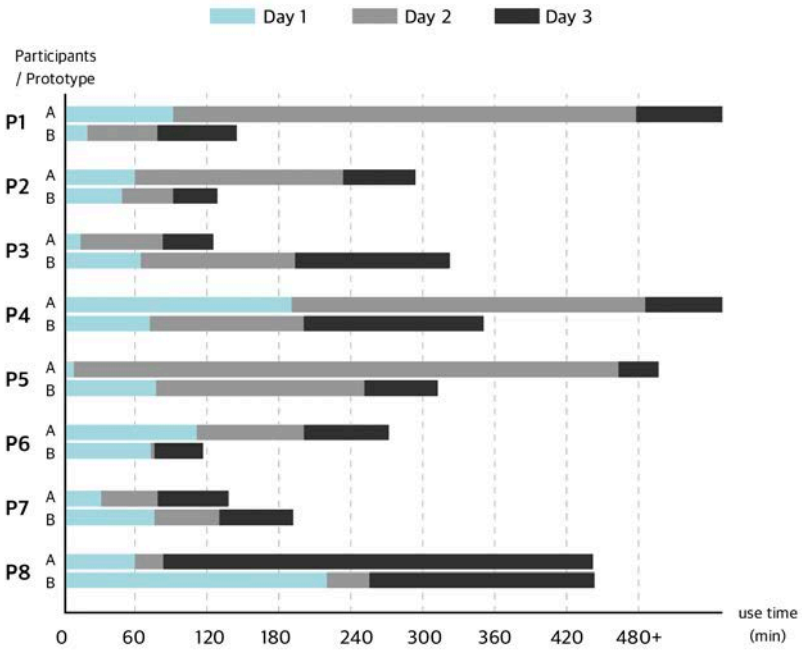

Figure 7. The total use amount of smartphone

Table 2 Awareness sensitivity between prototype A and B

Awareness sensitivity	Frequency of responses
Awareness of the amount of time spent using smartphone	A<B
Awareness of the amount of time left until sleep	A=B
Awareness of flow of time related to smartphone usage time	A<B

3.2 Self-reflection from usage awareness

Prototype B gave participants greater psychological pressure to stop using smartphones than prototype A (Table 3). Although smartphone usage time increased during using prototype B for two participants (P3 and P7), they mentioned that "I thought my smartphone usage time was definitely reduced because prototype B showed the usage time". This implies that prototype B induces psychological pressure to the user. Overall, users tend to prefer prototype A. According to the participants, prototype A played a role in gently telling them to sleep while prototype B was a warning to sleep.

Table 3 Degree of effect on self-reflection and preference between prototype A and B

The degree of effect on reflection through awareness	Frequency of responses
Discourage of smartphone use	A<B
Effect on actual behaviour	A<B
Preference	A>B

4 Discussion

4.1 Time of smartphone use

For the study, two experimental stimuli were created: prototype A is a bedtime reminder that shows remaining time till sleep and prototype B is one that also reflects the smartphone usage while showing remaining time till sleep. According to the results, prototype B could reduce the use of smartphone before sleep compared to prototype A. It led to the actual self-reflection, stopping smartphone use before expected time to sleep. It was also found that prototype B gave much psychological pressure to the user.

4.2 Arousal level with lighting

Although prototype B helped stopping smartphone use before sleep, all the participants preferred Prototype A. A possible explanation is that when the closer bedtime comes, lighting is reduced but in case of the prototype B, it continued to turn on the lighting that gives psychological pressure on user, so that they could self-reflection. This implies that the increased arousal level with light as time to sleep comes closer during using their smart-phone could make a feeling of repulsion.

4.3 The effect of ambient lighting

In this study, we applied the arousal level caused by using smartphone to the bed time reminder and developed it in the form of ambient notification. As a result, the participants gave very positive feedbacks about the ambient notification. They responded that at any moment of using the smartphone before sleep, the brightness of the light was reduced, and

the time flow was unconsciously felt. One participant mentioned “I prepared to fall asleep when I realized the brightness of the light was reduced.” It was also easily perceived that time to sleep was approaching, and the change of the color of the lighting gave a message that you had to sleep soon. Furthermore, P1 mentioned “This light was not just about telling the time to sleep, but it was also fun to recognize a specific remaining time... such as the bus time? Or the deadline.” P8 mentioned “Prototype A makes me do chores at home such as cleaning and laundry. Because Prototype A only works for the time I’ve set up. It made me not only reduce to use the smartphone before sleep but also know remaining time at which I could do some chores at home.” They liked the ambient light system because it does not disturb them. P1 said that if the bed time reminder was too bright while using the smartphone, it would disturb him, and he would feel negative emotion with the product.

Considering the feedbacks of the participants, we were able to confirm that giving notification of the remaining time through changes in color, brightness, and movement of light with ambient lighting can naturally tell time to sleep without disturbing users' main tasks and a feeling of repulsion.

5 Design implications

The study attempted to explore effective ways to let university students reduce the usage time of their smartphone before sleep in order to improve sleep hygiene. Showing remaining time to sleep or arousal level caused by smartphone use with ambient light were taken into account as variables. Based on the use experience of the participants, an improved design application can be suggested by combining prototype A and B (Figure 8): prototype A's function is that time to sleep is getting closer and at the same time it turns off incrementally. And prototype B’s function is that the bedtime reminder reflects time of smartphone usage. If each function is considered, it could influence awareness of the user in the context of smartphone use before sleep. The main feature of the new concept is that smartphone usage is reflected on the speed of turning off the light. In other words, the more user uses the smartphone, the faster it turns off the lights so that the sooner user get informed of time to sleep. And the less the user uses his/her smartphone, the slower it turns off the light so the later the user get the informed of bedtime. With the features, it is expected that it could contribute to reducing the use of smartphone before sleep.

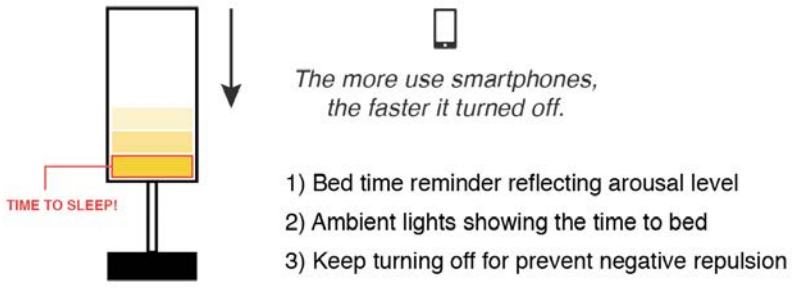

Figure 8. A bedtime reminder redesigned based on the findings from the experiment

6 Conclusions

In this study, we explored a way to reduce the use of smartphones before sleep. First, focus group interviews were conducted to understand the actual situation of smartphone usage before bedtime and to derive some insight about how to reduce smartphone use before

sleep. The major finding from the interview was that people would not recognize how badly smartphone use influence their sleep hygiene. Thus, it is believed that people could be aware of their smartphone use before sleep and end up with stopping using the smartphone for good sleep by letting people visually perceive the time of smartphone use and showing its impact on sleep (arousal level), Taking them into consideration, we developed two experimental prototypes with ambient light that can inform the bedtime and discourage to use smartphone in a less disturbing way. With the prototypes a field experiment with eight participants for six days was conducted in order to understand their effect and user experiences. As a result, we confirmed that bedtime reminders applying smartphone usage could increase participants' awareness of smartphone usage and sleeping time and confirmed that it could reduce the use time of smartphone before sleep. In addition, it was found that the ambient light that informs the sleep time could give positive emotions to people because it would not disturb the users' smartphone use. However, it has been also shown that the visualization of use time of smartphones with keeping turning on light may cause users a feel of repulsion. As a way to solve this problem, a new lighting system was suggested by combining the results of the study: changing its speed of turning off the light corresponding to the usage of smartphone. The findings from the study can provide a better understanding of smartphone use and sleep hygiene and are also expected to contribute to designing products or services related to sleep healthcare and smartphone addiction prevention. Nonetheless, the study has limitations. First, the period of experiment was not long enough to track their experience and actual behaviour change. Second, the sample size is not big enough to generalize the findings of the study. Therefore, it will be taken into consideration a greater number of participants and longer period of experiment. Third, a couple of limitations have provided an unnatural and uncomfortable situation for users: the user had to schedule at the appointed bedtime, and their smartphone had to be properly placed on the spot. Fourth, the results were limited in that data derived from the interviews and the time the stopped using smartphone. For this reason, we should reinforce these rationales through more accurate measurement of sleep time in a further study.

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Designing for the everyday through thusness and irregularity

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The concept of “everyday” is a central topic in design, and this paper argues for more attention and discussion on the everyday than what is currently done in design research. By elaborating what the everyday is, designers can better formulate a perspective on people’s lives and experiences, and therefore can better contribute to the enchantment of the everyday through designing. To contribute to this effort of clarification and enchantment, we first attempt to clarify the concept of everyday and thereafter suggest notions originating from Japanese philosophy to address the everyday in design. The everyday is described mostly through the process of quotidianisation of the unfamiliar towards the familiar. To support designing for the everyday, we propose to focus on Japanese notions: *thusness* and *irregularity*. *Thusness* invites to consider the experience of the *here-and-now* as being the active relation with the entirety of the world through interaction. *Irregularity* invites to keep something unexplained in the design, eliciting possibilities of exploration, openness, change, and the shift of perspective. Finally, three relatively practical design concepts, namely micro-considerations, micro-frictions, and (es)sential details, are proposed to support application of *thusness* and *irregularity* through design.

Keywords: everyday; thusness; irregularity; quotidianisation; Japanese philosophy

1 Introduction

The term “everyday” is a central topic in contemporary design, and is often used in design research literature (e.g., (Hallnäs & Redström, 2002; Norman, 2013; Saito, 2007; Wakkary & Maestri, 2007)). It usually refers to a banal context of practice or to what is ordinarily encountered. Therefore, it encompasses a large breadth of topics, from chairs to Internet-of-Things connected devices. However, it is hardly questioned as a concept in design research: what is the everyday? How does a design become an everyday design? How does

Discussing this apparent lack of tentative to describe and to characterise the everyday [Lévy, personal communication, April 4, 2017], a clear position was given by a professor in design: although understanding how design inquiries the everyday, the definition of the everyday appears to be too complex to be realistic. As he explained, the notion of everyday is part of a set of terms that are at the essence of design, and its interpretation varies according to the perspectives taken in and on design. In other words, defining the everyday would require defining design once for all.

Our viewpoint differs from what has just been suggested. It is certain that the definition of design is a complex and probably unsatisfiable enterprise. Yet the attempts themselves can be a strength for the discipline of design: the expression of a plurality of perspectives, and their crossing make possible a continuous fruitful reassessment of the discipline, as well as, consequently, its progress and the rich complexity of its very nature. Redström (2017, p. 6) argues even that "the presence of many different definitions is instrumental as we try to understand and articulate what things like "design" or "designing" are; this absence of unified definitions is not a conceptual shortcoming of our thinking but in fact an effective strategy for coping with certain kinds of complexity – although this is not something we have made explicit".

Questioning the everyday invites to explore and to point out its qualities and opportunities of transformation from a design perspective. Following the proposition of Debord (1961), questioning the everyday necessarily leads to transform it: "Studying the everyday life would be a perfectly ridiculous undertaking, and first condemned to comprehend nothing of its topic, if one was not explicitly proposing to study the everyday life in order to transform it." It is therefore a relevant topic for design research.

As for design, studying the everyday and attempting to describe what it is are not the aim to settle this notion, but to the contrary, it is to explore the territory of the everyday. The destination is incidental. Exploring the everyday is first of all to formulate a perspective on our lives and experiences, on the banal, and on design. Such exploration asks for an approach, often inspired from auto-ethnography (Lévy, 2018b) or ethnography (Wakkary & Maestri, 2007), through which design can transform the everyday, capturing and designing for its profound beauty. Studying the everyday through designing leads to enchanting the everyday. This is the objective of the research this paper belongs to.

Previous works (Lévy, 2018a) have shown that Japanese philosophy has inquired the everyday and can inform design research and design practice in a way that is lacking in the (mostly western-based) current design research literature. In this paper, we propose to clarify how two notions coming from Japanese philosophy, namely thusness and irregularity, may contribute to the consideration of the everyday in designing. To do so, we first describe the everyday based on the phenomenological description elaborated by Bégout (2010). Thereafter, we address the way design can consider and contribute to enchant the everyday through these Japanese notions.

2 Quotidianisation and Thusness

Let's consider a smartphone, an archetype of artefacts composing the everyday. During the first days of ownership, the product can be praised, both from the perspective of its design and of the related services. It is still to be explored in order to find new and potentially unexpected possibilities, functions that are yet unfamiliar. However, once the smartphone is used for a significant period of time, and as it becomes familiar, it starts to fade out in the everyday use. In a way, it becomes *flat*. First, it is physically flat, as a design attempt towards perfection in materiality (we will discuss a critical position on the value of perfection in the section 3). Second, it becomes "experientially flat", as the intelligence on board takes over our attention. This flattening is made possible by the immediate transparency of the interface, which is a "manifestation of the need to deny the mediated character of digital technology altogether" (Bolter & Grusin, 2000, p. 24). In other words, we aim to access information and services *as directly as possible*. Both types of the smartphone's flatness

support a process of habituation of the smartphone in the everyday. It is this process of habituation that we will clarify in the following.

2.1 Quotidianisation

Bégout describes such phenomenon as "a process of material organization of the uncertain world in a frequented environment, the work of overcoming the original misery of our condition by creating familiar forms of life" (Bégout, 2010, p. 313), using different techniques such as domesticity or habituation. This phenomenon is called *quotidianisation.* Moreover, quotidianisation is done in a context that is already largely *quotidianised* (Bégout, 2010, p. 385). Therefore, the aforementioned techniques are used to integrate what is unfamiliar into what is already familiar. Through this process, while interacting with already quotidianised artefacts as well as contributing to the quotidianisation of other artefacts, the everyday takes shape. Qualities of the everyday life relates to habituation, expectation, familiarity, proximity, tranquillity, harmony, ineluctability (of reality), proximity, detail or intimacy.

Everyday life is made up of what has been quotidianised, that is, the part of reality that is made habitual and liveable in peace and tranquillity, of what is therefore domesticated. Everyday life appears as the outcome of a process that is always active and never finished. It makes things usual, liveable with peace of mind, and therefore gradually escapes our amazement: this process therefore seems to "undermine the unknown and increase the déjà vu" (Bégout, 2010, p. 353).

The difficulty in approaching the everyday in design lies first and foremost in the fact of its familiarity, in its apparent obviousness, and therefore in its difficult questioning and analysis. Design needs to find in the everyday something to explore, to question, and to shape.

> *What is really happening, what we are experiencing, the rest, all the else, where is it? What happens every day and comes back every day, the banal, the everyday, the obvious, the common, the ordinary, the infra-ordinary, the background noise, the habitual, how to account for it, how to question it, how to describe it?*
> *Interview the usual. But we are used to it. We do not question it, it does not question us, it does not seem to be a problem, we live it without thinking about it, as if he did not convey any questions or answers, as if he was not carrying any information. It's not even conditioning anymore, it's anaesthesia. We sleep our lives from a dreamless sleep. But where is our life, where is it? Where is our body? Where is our space?*
> *How to talk about these "common things", how to track them down instead, how to find them, how to tear them out of the gangue in which they are stuck, how to give them a meaning, a language: how to finally speak about what is, about what we are.*
> *Perhaps it is a question of finally founding our own anthropology: the one that will speak of us, that will seek in us what we have looted from others for so long. No longer the exotic, but the endodontic.*
> *Perec (1989)*

2.2 Thusness

The invitation of Perec greatly resonates with the attention given to the *here-and-now* by Japanese culture and philosophy. In Japanese philosophy, the *here-and-now* can be roughly

be described as reality that one is aware of through *acting intuition*. The notion of *acting intuition*, proposed by Nishida (1987), relates to an understanding of reality made possible both through a reflexive and active grasp of the things of the world, and through a passive intuition by which one is grasped by things. The being is both object and subject in its relationship to things, in its relationship to the world. Therefore, the notion of *here-and-now* does not relate to the state of the present time, but to the active relation between the entirety world and the being in the world (which is, on another note, close to the theories related to embodiment (Dourish, 2001)). This nuance is significant: the *here-and-now* concerns the entirety of the world as experienced through what is perceived, rather than solely what is perceived. Therefore, one think about the thing as *that is*, rather than as *this thing is*. "*that"* is the thusness (or suchness – *shin'nyo* in Japanese) of the thing, which constitutes and is constituted by the entirety of the world. Thusness is "an existence prior to all distinctions, impossible to define except as being thus" (Lévi-Strauss, 2013, p. 96).

Considering *thusness* enables designers to consider reality as it is experienced. This makes it possible to take into account the everyday, i.e., the banal and the infra-ordinary, as well as the values that constitute it. Indeed, designers take advantage of this to understand the potential transformations caused by the introduction of a new design into reality, and also to understand how the design will potentially be quotidianised. The attachment to this reality requires the designer to focus not only on the material and social aspects of this everyday, but also on the way in which we can interact with them. The artefact must be designed with regard to the holistic consequences of decisions made during the design process. Each detail and its structural, performance, aesthetic, economic, contextual and ethical consequences matter, so that an iterative dialogue between prototyping (reflection-in-action) and formalization (reflection-on-action) appear effective (Schön, 1983).

From this perspective, thusness is a horizon that invites the designer to find a coherence between the qualities of the artefact and those of the reality it invests. In other words, the evidence of reality must be found in the evidence of the qualities of the artefacts, and then the thing is as *that* is. But this coherence of qualities does not in any way tend towards making reality static. The experience of these qualities through an interaction with the artefact is ethically pervasive both in activities and in time. Therefore, the ethically transformed reality transforms the perception and value of the artefact. Thusness as a horizon taken by design gives reality as it is lived, dynamic, aesthetic and ethical coherence through the experience of everyday life.

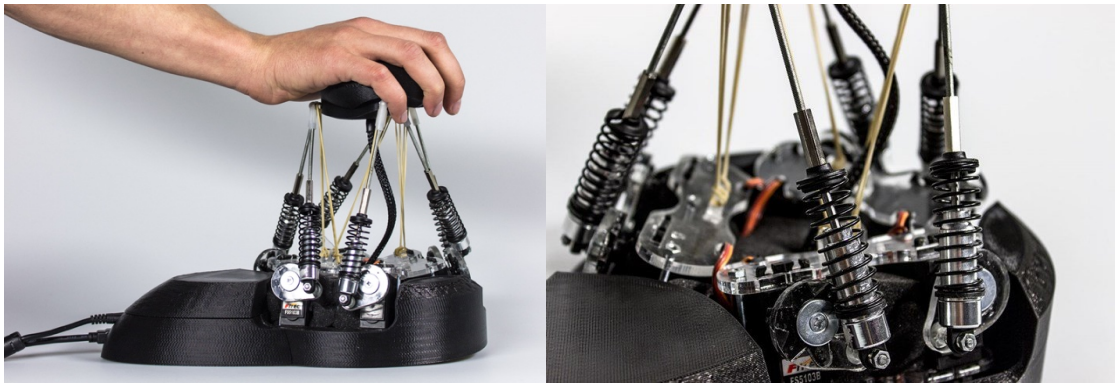

Figure 1. Stewart, designed by Felix Ros

An exemplifying project is Stewart, designed by Ros (Terken et al., 2017), which takes into account the complex relationship between the artefact and its environment and raises the ethical question of our relationship to that environment (cf., Fig. 1). Stewart is a tangible interface for fully autonomous vehicles (level 5). The core of the project addresses the relationship between the rich road environment, the autonomous and therefore potentially independent vehicle, and the passenger who is not anymore entitled to have control. Instead of focusing on interaction, the project raised the question of the relationship between the passenger and the vehicle that had become "intelligent", moving together in an uncertain environment. This relationship is proposed to be built on a dialogue. Stewart continually informs the passenger of the vehicle's behaviour and intentions. And it also makes it possible for the passenger to inform the vehicle if (s)he wishes the vehicle to change its behaviour or plans. A dialogue then takes place, allowing a constructive exchange leading to a relationship of trust, as the lack of trust in an autonomous technology launched at 100km/h is often cited precisely as a weak point of autonomous vehicles (Choi & Ji, 2015).

The main value of this design is the creation of a dialogue between the passenger and the so-called autonomous car as a result of considering this couple moving in uncertain environment. Instead of designing the interaction focusing on control, this design considers the car as an intelligent agent evolving in a (possibly urban and complex) landscape, and consequently considers the value of a dialogue between the two intelligent agents, the car and the passenger, moving together in this landscape.

3 Unfamiliar and irregularity

3.1 Unfamiliar

The dynamic nature of the everyday is also considered by Bégout (2010). The ambivalence of the everyday resides in the permanent oscillation between the experience of the familiar (in the quotidian) and the discovery of some unfamiliar or unexpected (in the *extraquotidian*), i.e., between the endotic and the exotic (Bégout, 2010, p. 44). The quotidianisation is possible because of both: the familiar supports the quotidianisation of the unfamiliar (cf. chapter 2.1). Therefore, the dynamic nature of the everyday is in the quotidianisation of the unfamiliar, which requires an attention to the unfamiliar as well as the familiar. Only through this attention, the quotidian can develop and enrich itself: the unfamiliar is contributing to the evolution of the everyday.

3.2 Irregularity

This notion of “contributing unfamiliarity” greatly resonates with the notion of irregularity proposed by Yanagi Sōetsu (1989). Yanagi is the founder of the *mingei* movement in the beginning of the 20th century in Japan. This movement is interested in craftsmanship by ordinary people and values that are "*modest but not cheap, cheap but not fragile. Dishonesty, perversity, luxury, these are what mingei objects must avoid at the highest level: what is natural, sincere, sure, simple, these are the characteristics of the mingei* " (Viatte, 2008).

In Yanagi’s view, because perfection is final, it is regulated, static, cold. It is therefore away of any possibility of openness and freedom, which he associates to beauty. Overcoming the apparent duality of perfection-imperfection, Yanagi insists as well that freedom is also not to be obliged to beauty, otherwise freedom would only be illusory. Not finding a better word,

Yanagi proposes the notion of *irregularity*, when “something remains unexplained”. Such beauty cannot be premeditated.

In contemporary industrial production, this irregularity can exemplary be found in the work of the textile designer Minagawa while pushing the embroidery machine to its mechanical limits (Minä Perhonen, 2005). At these limits, the machine creates unpredictable imperfections, source of unique and poetic beauty. We did a similar exploration (Lévy & Yamada, 2017) on the 3D-printing of whisks handles for the Japanese tea ceremony. Based on a parametric design (therefore transmitting “perfect” instructions to the 3D-printer), five whisk’s handles were printed at different speeds: the speed as recommended by the printer manufacturer, as well as two, three, four and six time faster. The whisks were evaluated by tea masters during a seminar. The second whisk handle, printed at twice the normal speed, was significantly most appreciated, precisely because of its subtle structural irregularities providing space for a permanent possibility to explore the artefact, for a potential surprise always renewed, while not being a clearly designed imperfection. The ambivalence of the imperfection makes it a beautiful irregularity.

Figure 2. Chasen handles, 3D printed at different speeds
(from left to right - 1,2,3,4,6 times the standard speed of the 3D printer)

Irregularity is therefore the essence of a force that leads to exploration, openness, change, and the shift of perspectives. It is not a design error, but on the contrary an opportunity for the artifact to be more than what is expected a priori. In other words, it is an overcoming of design: the aesthetic proposition contributes to an ethical transformation through the aforementioned shift of perspectives. Such irregularity is made possible if the designer accepts a partial loss of control of the design, necessary for the emergence of an irregularity.

4 Consequences for design

The enchantment of everyday life by design therefore invites the designer, and later the user, not to take her or his eyes off the ordinary (keeping thusness is the horizon) and to accept, and even to enhance in the case of the designer, small irregularities that make create openings for possible ethical transformations.

Attention to details appears to be a practical means by which designers cannot only keep an eye on the everyday, and therefore keeping thusness in the horizon and creating effective irregularities to enhance this everyday. We describe in the following three approaches that have addressed the design of details in accordance with the notions of the thusness and irregularity. The micro-considerations focus mainly on the structural aspects of the artefact,

the micro-frictions on interaction, and the *(es)sential details* on the experience. Even if these first two approaches can be considered independently of each other in the context of a design practice, they are nevertheless complementary, and their relationship seems not only enriching but also contributing to a design that takes into account *(es)sential details*.

Through the concept of *micro-consideration*, Fukasawa (2015) suggests to keep an eye on the ordinary, through focusing on details. He invites to design for details taking into considerations the way people act in the everyday. An example of such micro-consideration is embedded in the design of the muji rice cooker (Rice cooker / MUJI / 2014) (Fukasawa, 2014). On top of the rice cooker, a small straight mound is added to place the back of the rice spoon. Putting the spoon on top of the cooker is a fairly common action in Japanese households, yet it seems that muji is the first one who took this action into consideration in the design. The aim of such micro-consideration is, according to Fukasawa, to ensure that the product offered by muji is sufficient ("muji is enough"), i.e., that it corresponds exactly to what the customer had in mind when entering the store, without overdoing it. In the terms used by this paper, the customer perceives the thusness of the product. To do this, Fukasawa observes what people do without thinking about it: the banal in their actions. Thereafter, he integrates what he has observed into his thinking and design. Thus, the design created is quietly integrated into the daily lives of its users.

Considering the interaction aspects in designing and inspired from the micro-boundaries proposed by Cox et al. (2016), *micro-frictions* are small moments of friction taking place in interaction during an activity, which divert from the expected without significantly disturbing the objectives of the activity and disrupting the course of this activity. They are a form of friction that only briefly surprises the user's ordinary by a form of irregularity. They briefly surprise the experience and invite the realization of the quality (good or bad) of the *here-and now* by means of an irregularity through the course of interaction.

Finally, the process of determining a set of qualities essential to the creation of value in interaction is at the heart of an education project led by the authors for several years, named "*(es)sential details"*. What makes a detail essential is that it reveals an interacting beauty whose quality is most important to achieve a form of irresistibility (Andersen, 2013). The details considered in this project can be of a physical or interactive materiality (Stienstra, Alonso, Wensveen, & Kuenen, 2012) and engage in a reflection through design on the place of detail in the emergence of interactive beauty.

5 Conclusion

We pointed out the paucity of addressing the notion of everyday in design, and motivated the challenge and the ambition of such address. Rather than attempting to define the everyday, we suggest engaging in an open reflection on the everyday in order to propose means for its enchantment through design. The main challenge seems to find conceptual means to question the everyday, that is the obvious and the familiar.

Thusness and irregularity enable to start addressing the everyday through designing. It invites us to consider first the context of the design to comprehend the situatedness of the interaction (including the banal and other elements that constitute the everyday), rather than considering first the interaction itself. Irregularity provides a balance in the consideration of the familiar, by keeping opportunities for the surprises, for the opening of spaces of possibilities. Irregularity, that can be addressed through various operationable approaches

(micro-considerations, micro-frictions, *(es)sential details*), is paramount in regard to the creation of beautiful uncertainty in everyday experiences.

These irregularities break the seamless flow of interaction with the expected, and therefore invite the user to *really* see and appreciate the artefact (s)he is interacting with. It brings the attention of the user to the *here-and-now*. Such impact requires the designer to also pay attention to the *here-and-now*, and by extension to the everyday. Even if this framework can undoubtedly be applied to a situation other than everyday, it finds all its strength in the everyday and the banal. Everyday practices and the arts of doing should be for the designer a point of attention and of concern at least as important as the artifact to be designed. What we do, our interactions, our reflections, etc. constitute our daily experience. Artifacts, possibilities of action and of unexpected events are means for such experience.

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Designing for Wild Life: Enabling City Dwellers to Cohabit with Nature

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People benefit from living alongside nature. Yet we face a troubling scenario of alarming global biodiversity decline, vast loss of greenspace to urbanisation, and harmful disconnection of city dwellers with nature. This is a particular problem in existing residential streets, which make up a significant proportion of UK cities and could offer substantial greenspace and wildlife habitat.

Living with increased contact with nature, people would benefit from better health and wellbeing. Moreover, greening the city would improve air quality, and reduce overheating and flood risk. But policy to increase greenspace and its biodiversity focuses on the easy target of new developments and public spaces; and guidance for the public lacks urban emphasis, street-scale thinking and design oversight. Meanwhile, management of greenspace in domestic gardens is largely unregulated and residents underestimate its importance for environmental functions, including providing wildlife habitat.

Design research could enable city residents to change how they live, with designers using their skills to communicate a better way to live alongside nature in cities. A practice-based case study, 'Rewild My Street', seeks to inspire and empower London residents to adapt their own homes, gardens and streets for wildlife. Through architectural drawings, product specification and a spatial manifesto, the project shows a vision of a residential city street adapted for living in harmony with nature. This offers a design-led template for creating a global network of biodiverse, sustainable cities.

Keywords: living; biodiversity; greenspace; architecture; urban rewilding; residential; National Park cities

1 Research Focus: Designing Nature into the City

People benefit from living alongside nature, especially in cities. Spending time in a natural environment lowers our pulse rate, blood pressure and cortisol levels (Park, Tsunetsugu, Kasetani, Kagawa & Miyazaki, 2010), and makes us feel mentally restored (White, Phal, Ashbullby, Herbert & Depledge, 2013). This perhaps explains why people living in urban areas with more green space report better general health (Maas, Verheij, Groenewegen, de Vries & Spreeuwenberg, 2006). Greenery can help tackle environmental and social problems associated with cities: improving air quality by blocking and dispersing pollutants (Air Quality Expert Group 2018); reducing overheating and surface flooding through shading, evapotranspiration and infiltration (Blanusa & Page, 2011); and even reducing crime (Kuo &

Sullivan, 2001). Further, places that are good for wildlife tend to be good for people. The more biodiverse an urban greenspace the more it benefits our psychological wellbeing (Fuller, Irvine, Devine-Wright, Warren & Gaston, 2007). Greening cities for biodiversity therefore benefits human inhabitants by enhancing their health and wellbeing, and improving their living environment.

Despite the benefits of nature to humankind, we are causing alarming global biodiversity decline, vast loss of greenspace to urbanisation, and harmful disconnection of city dwellers with nature. Global wildlife populations have suffered a 60% decline since 1970, due to human activity (Grooten & Almond, 2018). City greenspace, with value for wildlife and people, is being lost through the parallel phenomena of urban sprawl (WWF, 2017) and densification (Haaland & Konijnendijk van den Bosch, 2015). Reducing our access to greenspace in this way is akin to self-harm, when a correlation has been shown between contact with nature and human life expectancy (Poudyal, Hodges, Tonn & Cho, 2009).

Loss of vegetation is a particular problem in existing residential gardens, which make up one quarter of a typical UK city (Thompson, 2019) and could offer substantial wildlife habitat (Blanusa & Page, 2011). A quarter of UK front gardens are entirely paved, reflecting a threefold increase in the past decade (RHS, 2019).

London is a case in point, losing greenspace at a rate of 2.5 Hyde Parks annually as a result of changes in domestic gardens (Smith, 2010). These changes concern the replacement of trees, lawns and flowerbeds with hard surfaces and outbuildings, dramatically reducing the biodiversity value of the individual gardens and, moreover, their cumulative value to the neighbourhood and overall city (Smith, 2010). The London Wildlife Trust therefore identifies a need for urban versions of rural rewilding projects to restore greenery and biodiversity (Frith, 2016; Rewilding Britain, 2014). This will be difficult when residents underestimate the importance of their gardens for environmental functions, such as providing wildlife habitat (Smith, 2010).

The paper explores whether design could take on this challenge by influencing city dwellers to rewild their own residential streets. This is analysed through a case study that seeks to provide a model for the redevelopment of London, and, ultimately, a global network of biodiverse cities.

The study therefore tackles the research question, ‘Could a vision of a rewilded urban street engage residents to adapt their homes for wildlife?’ This raises the sub-questions:

- How should a vision of living with nature be communicated to inspire the public?
- How can the vision be informative to enable residents to carry out the adaptations shown?
- How should wildlife features be sensitively integrated within an existing urban context?
- How can the vision allow for diversity in its interpretation?
- How can vision drawings be used to organise expert external guidance and make it relevant to urban contexts?

This research addresses the Living track by aiming to use design to shape how people live in relation to nature, and to make cities better for both the people who live in them and the diverse wildlife that could live in them. It explores how design can enhance our lives by improving the environment, at both the local and global scales: locally, by making city streets

more liveable, increasing city residents' access to greenspace and contact with nature; and globally, by mitigating biodiversity loss and the effects of climate change. It seeks to use design to influence the way people think about their street's potential for urban wildlife, and the actions people take or products people buy to make their homes more biodiverse.

2 Research Context: Other Research, Policy and Guidance

The current context sees biodiversity research focused on new-build housing; guidance for the public lacking urban emphasis, street-scale thinking and design oversight; and policy to increase greenspace and its biodiversity focused on new developments and public spaces.

2.1 Biodiversity and Housing Research

Other research aims to address biodiversity decline through housing design. Barratt Homes and the Royal Society for the Protection of Birds (RSPB) are jointly studying biodiversity in new-build housing with integral wildlife features (Thomas, 2018). This study is on a greenfield site and aimed at changing how people live by influencing new-build developers, rather than residents of existing, urban housing stock.

2.2 Biodiversity Guidance

Several organisations offer expert online advice to encourage the public to manage their gardens for greenery and wildlife. These include RSPB's 'Give Nature a Home' (RSPB, 2019) and the Royal Horticultural Society's (RHS's) 'Greening Grey Britain' (RHS, 2019) campaigns. Conservation bodies, such as RSPB and the Wildlife Trusts, have information about particular species and habitats on their websites. This guidance is not design-based and tends to focus on adaptations to individual gardens, with limited consideration of buildings or streets; it is nationwide, therefore not specific to urban contexts.

Some conservation organisations recommend wildlife products for particular species. However, there is a lack of design-based advice on selecting products for integration in urban settings.

A number of community-based demonstration projects are helping city residents implement changes to their environment for wildlife. These include the Wildlife Trusts' 'My Wild City' in Bristol (Avon Wildlife Trust, 2019), and wildlife garden award scheme in Exeter (Devon Wildlife Trust, 2019); and Earthwatch Institute's 'Naturehoods' in Oxford and Swindon (2019). These are on-the-ground projects without a design agenda of creating a masterplan for sensitively integrating wildlife provision within streets.

2.3 Biodiversity and Green Infrastructure Policy

UK targets are in place to protect biodiversity (HM Government, 2011). Biodiversity policy in the UK includes a chapter of the national 'Strategy for Sustainable Construction' (HM Government, 2008), the Mayor of London's regional 'Environment Strategy' (2018), and biodiversity planning guidance for some local authorities (Hackney Council, 2011). These all focus on new developments or public spaces, rather than existing, residential streets.

Regulation can do little to change the impact of private garden management when existing gardens are largely beyond the remit of local government (Gaston, Smith, Thompson & Warren, 2005). Policies that do exist restrict the area of front gardens that can be paved over without planning permission (Communities and Local Government & Environment Agency, 2008), removal of trees with significant amenity value to a neighbourhood (Communities and Local Government, 2012) and unacceptable housing development within back gardens

(Smith, 2010). These were not implemented for the direct benefit of biodiversity and do not therefore stipulate protecting vegetation, hedges and shrubs, or controlling the construction of garden outbuildings.

The study aims to address gaps in the above research and guidance by tackling existing urban housing at street scale and taking a new perspective centred on design research. It intends to reframe the existing guidance for urban residents and signpost it with design oversight. It seeks to circumnavigate the shortcomings in policy by using design models to enable community action.

3 Methods: Architectural Design Process

3.1 London Setting

The context of London was chosen for the study, as the capital has aspirations to celebrate and increase its greenspace, yet is particularly affected by loss of garden wildlife habitat.

The capital already boasts 47% green and blue space (Mayor of London, 2018), despite being the UK's most populous conurbation (Office for National Statistics, 2018). Its greenness has been acknowledged by official recognition as the world's first National Park City (London National Park City, 2019). This is bolstered by targets from the National Park City Foundation to make the city 'greener, healthier and wilder' (London National Park City, 2019), and from the Mayor of London to add 12% tree cover and raise greenspace to 50% by 2050 (Mayor of London, 2018).

Private gardens will be important in achieving this, as they constitute nearly a quarter of the capital's land area and connect other habitats (Mayor of London, 2018), but a ten-year study found hard surfaces in the city's domestic gardens had increased by 26%, while vegetation decreased by 12%, having a notable adverse impact on their value as wildlife habitat (Smith, 2010).

In light of the limitations of regulation in gardens, there is a need to educate Londoners on the contribution their gardens make to the city's overall greenspace and biodiversity, and on how to adapt and manage their own gardens with this in mind. This could in turn encourage communities to lobby their borough councils to make changes to their streetscape. A new model for implementing policy by empowering communities is therefore needed.

The case study project, Rewild My Street, was set up to provide this model by creating a design vision and guidance to inspire and empower Londoners to adapt their homes for wildlife.

3.2 Architectural Design Process

The project used practice-based design research methods to interrogate the aforementioned research questions. Specifically, it followed the architectural practice research methods promoted by the Royal Institute of British Architects (RIBA, Research in Practice, 2013). An expert design team followed an iterative design and drawing process to test ideas, using architecture, landscape and urban design thinking. The process consisted of activities mapped to project Work Stages 0 to 3, as set out in the RIBA's Plan of Work (2013), which are routinely followed by practicing architects in the UK.

3.2.1 Stage 0: Strategic Definition

The first stage involved identifying the strategic brief and assembling the design team.

The strategic brief derived from the primary research question, ‘Could a vision of a rewilded urban street engage residents to adapt their homes for wildlife?’, which set the strategy to develop a vision of a rewilded urban residential street. The design was applied to the baseline of a notional typical London residential street, defined in the study by the Victorian (1837-1901) terraced housing typology, due to its prevalence in most London boroughs. Given the urban context, the definition of ‘rewilding’ as ‘returning areas of land to a wild state, including the reintroduction of animal species that are no longer naturally found there’ (Harper Collins, 2019) was reinterpreted to mean that the proposed design should return a street to a greener, more biodiverse state by adapting it to accommodate a wide variety of plant and animal life. In terms of the scope of the design, ‘homes’ were taken to mean all parts of the private domain, including the house, front and rear garden, and outbuildings; the definition also extends to the street, while acknowledging that this would usually be in public ownership and that residents would therefore need to petition their local council to make interventions here.

The project was carried out by a design team with relevant expertise, led by an architect. The team consists of architects and ecologists. Design is inextricably linked to the designer’s personal perspective, so it was necessary that the architects could draw on years of experience in practice, including expertise in existing and residential buildings in London; as well as specialist knowledge in sustainable design, including design for biodiversity. Similarly, the ecologists, who were consulted for feedback on the proposals at key stages of the project, needed to be proficient in providing consultancy for biodiverse London developments. These personal perspectives enabled the design team to understand the subject and make considered design decisions.

3.2.2 Stage 1: Preparation and Brief

This stage required the architects to develop project objectives, including project outcomes; develop the project brief; and review site information.

The research sub-questions determined the project objectives: to communicate a vision of living with nature in a way that should inspire the public; to make that vision informative, so that residents could carry out adaptations to their homes; to sensitively integrate wildlife features within an existing urban context; to allow diversity of implementation options; and to use drawings to organise expert external guidance and make it relevant to urban contexts.

To achieve these objectives, the project outcome was decided as a set of architectural drawings accompanied by a spatial manifesto and compiled in an online resource. These would show how the notional typical residential street could be adapted to increase its biodiversity. The drawings would consist of a concept collage; and street-scale plan, elevation, sectional perspective and isometric projections at 1:1250. The project brief was developed to work towards this outcome.

Information was gathered on a notional site by visiting and researching photographs of Victorian homes and streets, then surveying a typical Victorian house and street to create an accurate drawing using Computer Aided Design (CAD) software.

3.2.3 Stage 2: Concept Design

In this stage, activities included preparing concept designs and finalising the brief.

Concept designs were made using hand-drawn, annotated sketches. These went through many iterations to arrive at a template for what information would be included on each drawing.

Figure 1. Sketch for sectional perspective drawing. Source: Siân Moxon

The design concept of a rewilded urban street was consolidated by producing a concept collage, using image-editing software. This depicted a grey existing street overlaid with planting and recolonised by diverse species of wildlife that could be found in an urban setting.

Figure 2. Concept Collage showing project vision. Source: Siân and Jon Moxon (with altered photographs courtesy of Daniel Case, Super.lukas, Didier Descouens, Ninjatacoshell, Peter Mulligan, Claus Rebler, Karen Arnold, Potapov Alexander/Shutterstock).

The concept was developed by writing the following spatial manifesto, which describes the project vision in words:

> Take a typical London residential street. Adapt its terraces, gardens and streetscape to transform it into a haven for wildlife. The street will come back to life: the bees will be buzzing, the birds will be singing, the frogs will be hopping and the owls will be hooting. The changing seasons and the pattern of day and night will be seen from every living room - while children growing up on the street will have nature on their doorsteps.
>
> No more paved over front gardens, no more felled street trees, no more synthetic lawns. Bring back real greenery and real life. Every small change will add up to make a big difference.
>
> Just add wildflower meadows, patio ponds, bird boxes and feeders, and insect hotels. Puncture the fences to link up back gardens, forming mammal corridors. And watch the wildlife return in droves.
>
> While addressing the alarming decline in biodiversity, the newly green streets will improve air quality, and lessen urban overheating and flood risk associated with climate change. Londoners will benefit from improved health and wellbeing through better access to nature.
>
> Gardens cover a quarter of London and existing buildings will remain with us for years to come. For a lasting legacy, we must enable these spaces to accommodate nature, turning the whole city into a National Park to make future generations proud. Rewild My Street will do exactly this.

The brief was developed by analysing precedents that were judged to present design information in an engaging and informative way. These included visual communication techniques, such as infographics, and other design-research projects, such as ‘A Pattern Language’ (Alexander, Ishikawa, Silverstein, Jacobson, Fiksdahl-King & Shlomo, 1977) and the ‘101 Rules of Thumb’ series (Heywood, 2013 & 2015). These make engaging use of drawings and diagrams as templates for architecture and sustainable design, respectively, which could be applied to illustrate design for biodiversity for a lay audience. Qualities contributing to their effectiveness were identified as simplicity, use of hand drawing and colour, and use of focused annotation.

This research helped to establish effective presentation methods that would be used to produce the final drawings. It was decided to use hand-drawn line drawings, rendered using image-editing software for most of the drawings. The aerial view was produced using image-editing software alone, as the designers felt this three-dimensional view would benefit from a different character to set it apart from the other, two-dimensional projections. The drawings would be cross-referenced through simple keys to external guidance on associated species, habitats, products and DIY activities to help people implement the depicted adaptations.

3.2.4 Stage 3: Detailed Design

This stage concerned preparing a developed design, including outline specifications.

The concept sketches were redrawn to scale on CAD to a basic level, then printed and overlaid to set up detailed drawings in pencil to form the basis of the hand drawings. At this stage, the drawing process was used to test ideas for how to successfully integrate wildlife measures into existing properties, targeting adaptations to encourage species likely to colonise urban settings. Once the design team was content with the proposals, the hand

drawings were traced over these as black line drawings, using two pen thicknesses to achieve the desired appearance of simplicity. These were scanned and embellished in image-editing software to show textures, colour, shadows, and inhabitation by people and animals.

Outline specification was informed by extensive product research, taking into consideration the recommendations of conservation organisations. Most of the products were either tested by the architects on a London residential property or inspected as samples. The ecologists were consulted to advise from their experience of testing products on built schemes. Preference was given to products manufactured by environmentally conscious companies, local to London or the UK.

3.2.5 Stages 4 to 7

The project is set up to empower residents to carry out Stages 4 to 7 of the RIBA Plan of Work (representing Technical Design, Construction, Handover and In Use) themselves, by giving practical guidance on implementation in the preceding stages, as described above. Nevertheless, these phases are crucial to the project's success, as they are when the effects on people's lives will happen. Construction, when people install a purchased product or make a home for wildlife by following an activity, is when residents will become most active in the project process and feel they are doing something worthwhile. During use is when residents will benefit from their adaptations, enjoying additional greenery and wildlife on their street, and carry out any recommended maintenance. During these stages, there is the facility for residents to ask questions about installation or give feedback on the effectiveness of their installations through the website.

It was important for the design team to evaluate the impact and potential of the drawings and web resource following the detailed design stage. This was done both through internal critical review and external feedback, particularly from audiences outside the architectural profession. Feedback was sought by entering competitions and awards, monitoring social and mainstream media interest in the project, encouraging people to sign up to the website, and conducting a survey by questionnaire.

4 Findings: Vision Drawings and Web Resource

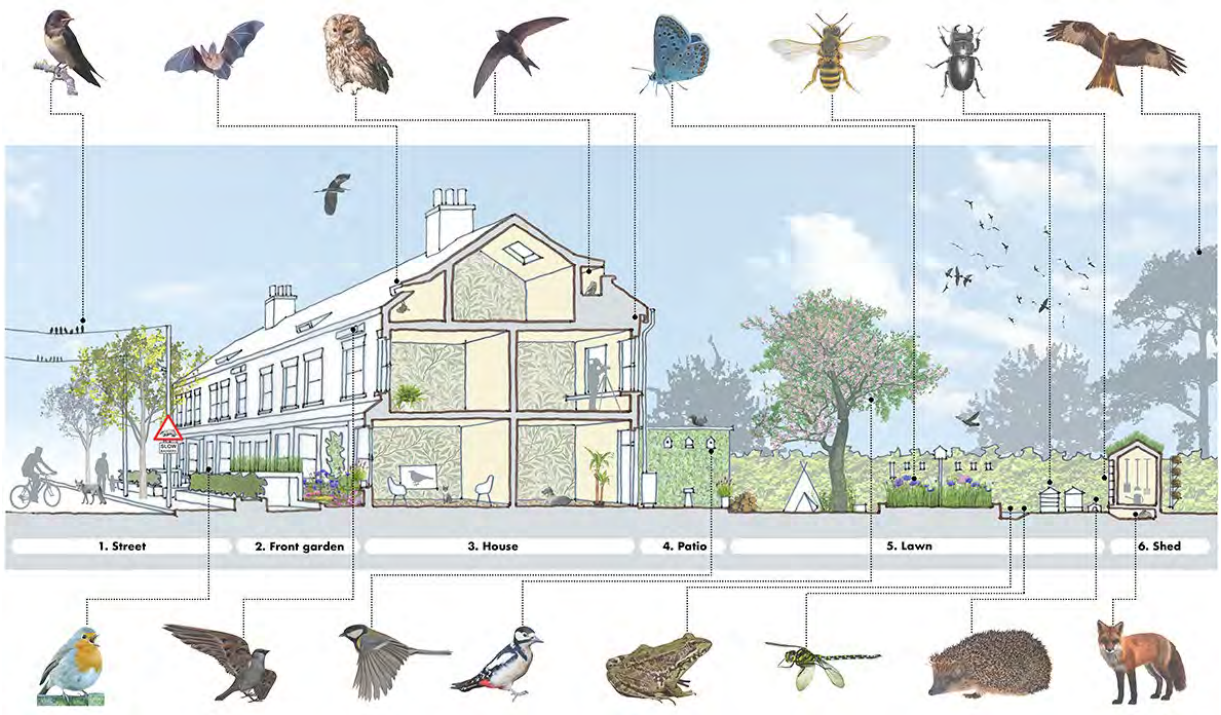
The design process described above has resulted in a vision for living in harmony with nature in our cities, shown through the concept collage, spatial manifesto and set of vision drawings of a rewilded London street.

The nature of the vision is one of streets full of greenery where people live surrounded by wildlife. Yet it remains a street with urban character, where wildlife habitat is neatly and appropriately incorporated within the architecture, garden design and streetscape. It is also a vision of community spirit and cooperation, where residents take responsibility for their environment, individual actions contribute to a greater whole, and people play and socialise in the street. Further, it is a vision of a healthier place for people to live, where residents will enjoy better physical health and emotional wellbeing, along with better air quality, temperature control and flood protection.

This vision has been encapsulated in and used as the basis of a design toolkit through the rewildmystreet.org website. Here, the concept collage and manifesto are used to introduce the project and its mission.

Each vision drawing is employed for a different purpose on the website, using a key to cross-reference the drawing to relevant expert external guidance. Although the drawings form a comprehensive set, showing the same adaptations to the street, this allows individual drawings to be used to organise information on wildlife species, wildlife habitat, products for wildlife, and activities to attract wildlife. This guidance takes the form of external links to expert organisations or manufacturers identified by the literature review, and has been carefully selected and compiled to be relevant to urban contexts. In this way, the resource collates diverse external guidance, combining educational information on the importance of managing streets for wildlife with practical advice on how to achieve this.

Most of the keys are organised by the street, front garden, house, patio, lawn and shed zones identified on the drawings to help people locate a particular wildlife feature and find out more information about it.



Species	Guide
Mammal	The Mammal Society
Badger	The Mammal Society
Bats	Bat Conservation Trust
Deer (Muntjac)	The Mammal Society
Fox	The Mammal Society
Hedgehog	Hedgehog Street
Mole	The Mammal Society
Mouse (Wood)	The Mammal Society
Otter	The Mammal Society
Rabbit	The Mammal Society
Rat (Brown)	The Mammal Society
Shrew (Common)	The Mammal Society
Squirrel (Grey)	The Mammal Society
Vole (Field)	The Mammal Society
Water Vole	The Mammal Society

Species	Guide
Bird of prey	Hawk & Owl Trust
Hobby	Hawk & Owl Trust
Kestrel	Hawk & Owl Trust
Owl (Tawny)	Hawk & Owl Trust
Peregrine	Hawk & Owl Trust
Red Kite	Hawk & Owl Trust
Sparrowhawk	Hawk & Owl Trust

Species	Guide
Bird (other)	RSPB
Blackbird	RSPB
Black Cap	RSPB
Black Redstart	RSPB
Crows	RSPB
Ducks/geese/swans	RSPB
Dunnock	RSPB
Finches	RSPB
Goldcrest	RSPB
Gulls/terns	RSPB
Heron (Grey)	RSPB
Nuthatch	RSPB
Parakeet (Ring-necked)	RSPB
Pigeons/doves	RSPB
Robin	RSPB
Sparrows	RSPB
Starling	RSPB
Swallow/martins	RSPB
Swift	Swift Conservation
Tits	RSPB
Thrushes	RSPB
Wagtails	RSPB
Warblers	RSPB
Woodpeckers	RSPB
Wren	RSPB

Species	Guide
Amphibian/reptile	Froglife
Adder	Froglife
Frog (Common)	Froglife
Grass Snake	Froglife
Lizard (Common)	Froglife
Newt (Great Crested)	Froglife
Newt (Smooth)	Froglife
Slow Worm	Froglife
Toad (Common)	Froglife

Species	Guide
Invertebrate	Buglife
Ants	Buglife
Bees/wasps	Buglife
Beetles	Buglife
Bumblebees	Bumblebee Cons. Trust
Butterflies	Butterfly Conservation
Flies	Buglife
Grasshoppers/crickets	Buglife
Lacewings	Buglife
Mayflies	Buglife
Millipedes/centipedes	Buglife
Moths	Butterfly Conservation
Slugs/snails	Buglife
Spiders	Buglife
True bugs	Buglife
Woodlice	Buglife

Species	Guide
Plant/fungus	Plantlife
Fungi	Woodland Trust
Trees/hedges	Woodland Trust
Wildflowers	Plantlife

Figure 3: Sectional perspective showing proposed typical house and street with adaptations for biodiversity, focusing on species. Source: Siân and Jon Moxon (with altered photos courtesy of Charles J Sharp, Pau.artigas, Super.lukas, Didier Descouens, Ninjatacoshell, George Hodan, Piotr Siedlecki, Peter Mulligan, Potapov Alexander/Shutterstock).

The sectional perspective is used to highlight species of wildlife that might be attracted to an urban street. The drawing uses images of key species with leader lines indicating where they

might be found: for example, a swift is shown with a leader line pointing to a swift box on the rear wall of the house. Some of the larger animal species are also shown populating the house and garden to give the image a sense of animation. The key contains links to information on prospective species, in this case categorised by mammal, bird of prey, other bird, amphibian or reptile, invertebrate, and plant or fungus.

This drawing was deemed successful by the design team in enabling residents to envision how they could live in greater harmony with a diverse range of species.

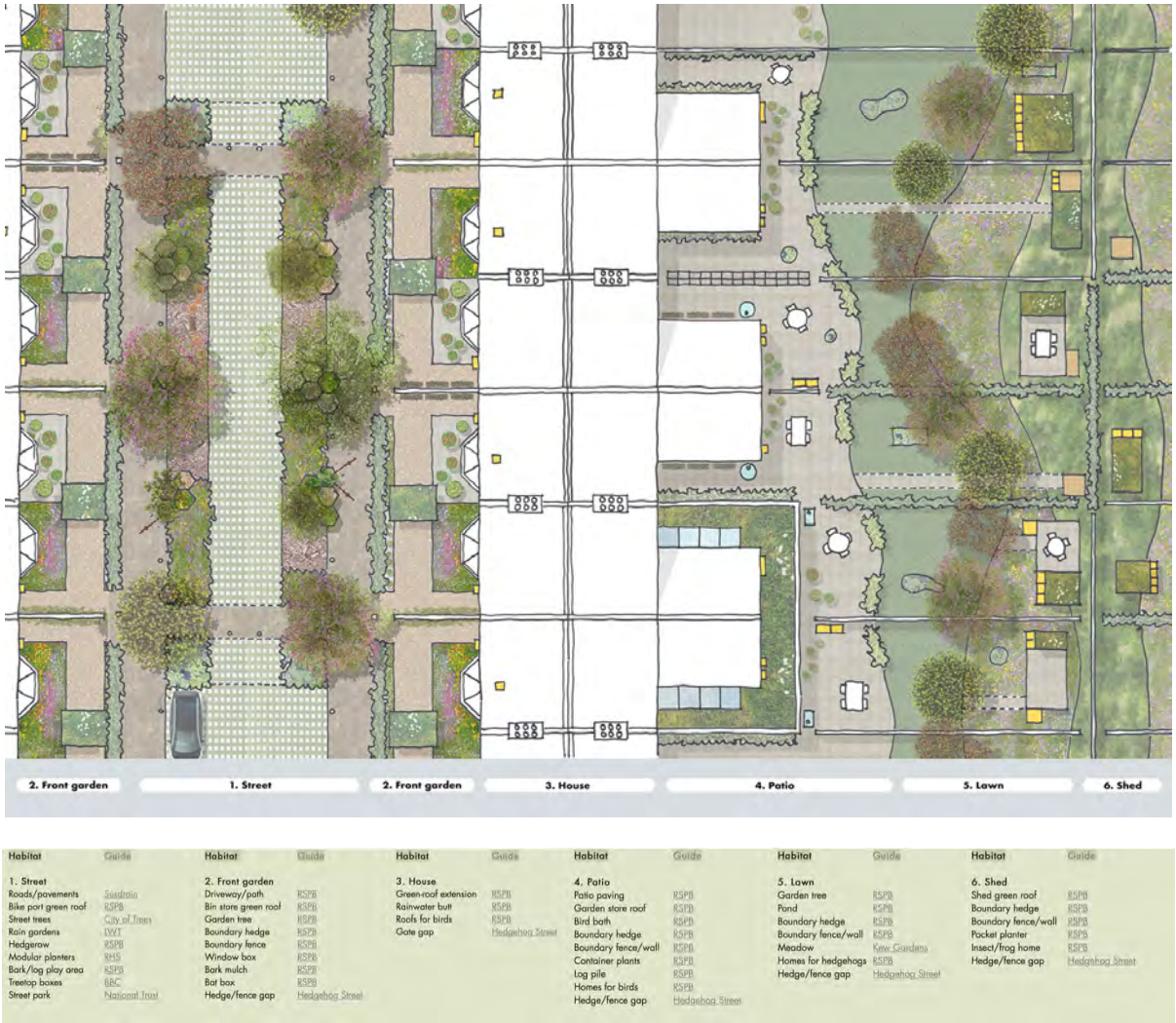


Figure 4: Street plan showing proposed typical street with adaptations for biodiversity, focusing on habitat. Source: Siân & Jon Moxon, Viktoria Fenyes.

The street plan in used to show types of natural habitat that could be created in an urban environment, categorised as green roof, trees, water, hedgerow, green wall, wildflowers, dead wood, habitat box and wildlife corridor. Its key compiles links to information about such habitats, organised according to the zones to help residents identify where in the street this habitat might be best suited. For example, the wildflower habitat is suggested as a meadow in the lawn zone; and the green roof is proposed on the bin store and shed, in the front garden and shed zones, respectively. The plan emphasises the potential for continuity of habitats across garden boundaries - depicting a continuous hedge in the front gardens and a stylised wave of meadows in the back gardens - facilitated by wildlife gaps shown in the

boundary fences. This uniformity is balanced by a sense of individuality, with some houses indicating nest boxes and others preferring ponds, but all contributing something to the overall mosaic of habitats offered by the street. These simple adaptations are juxtaposed with more radical interventions in the street, not least the car-free street park. Although this feature would require local authority investment and implementation, it is designed to be wholly viable, being based on modular components that fit within the existing street layout and leave clearance for emergency and maintenance vehicles.

The design team considered this drawing effective at conveying to residents that they could live in a much greener environment that provides a patchwork of connected habitats.

The street and back garden elevations are employed to highlight off-the-shelf products that can be purchased to benefit wildlife. The key for the elevations includes suggested products with links to retailers, again organised by the zone the product is depicted in. Products have been selected for their suitability for an urban setting, for instance using contemporary design or modern materials, and being suited to retrofit in small spaces or on vertical surfaces. Products have also been chosen to suit wildlife species that are known to thrive in cities.

The design team was confident these drawings could influence the products people buy, making it easy for city dwellers to source products that suit an urban setting and attract urban wildlife species.

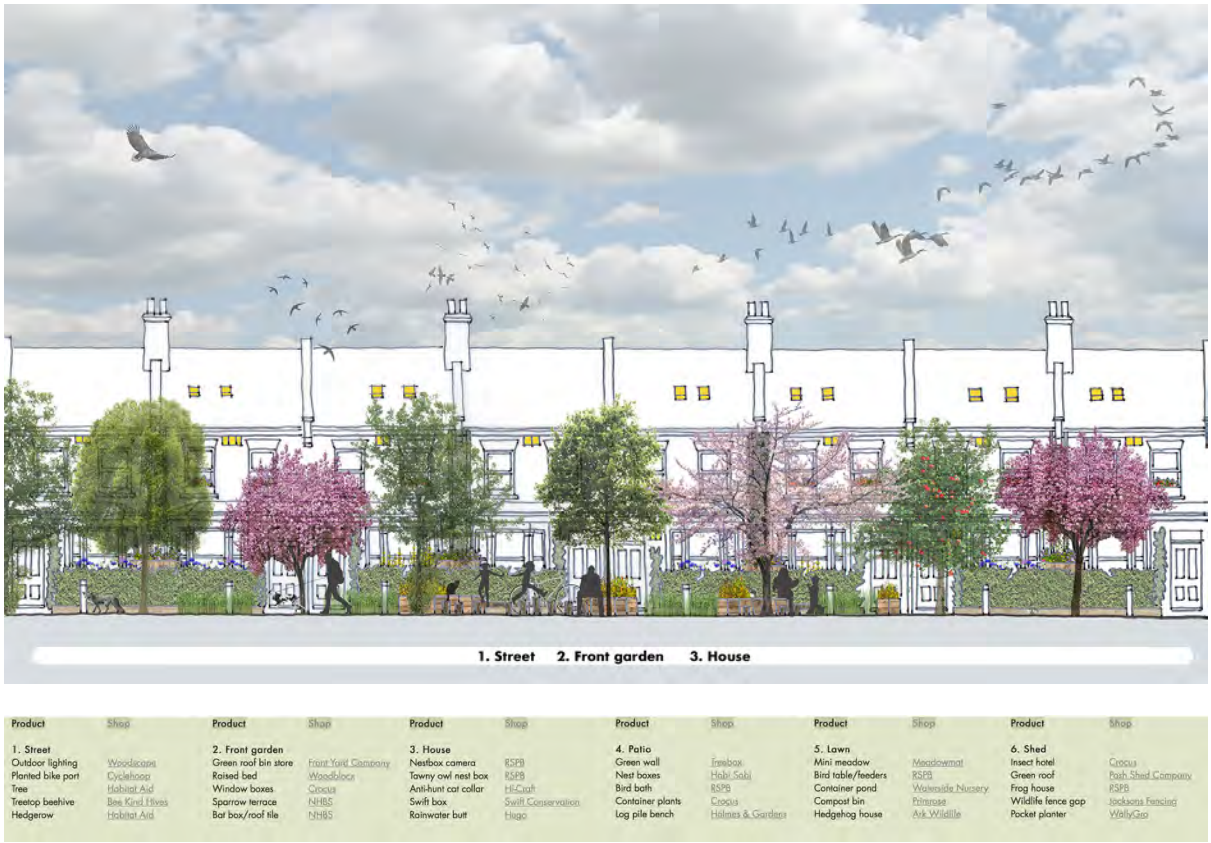


Figure 5: Street elevation showing proposed typical street with adaptations for biodiversity, focusing on products. Source: Siân & Jon Moxon, Viktoria Fenyes.

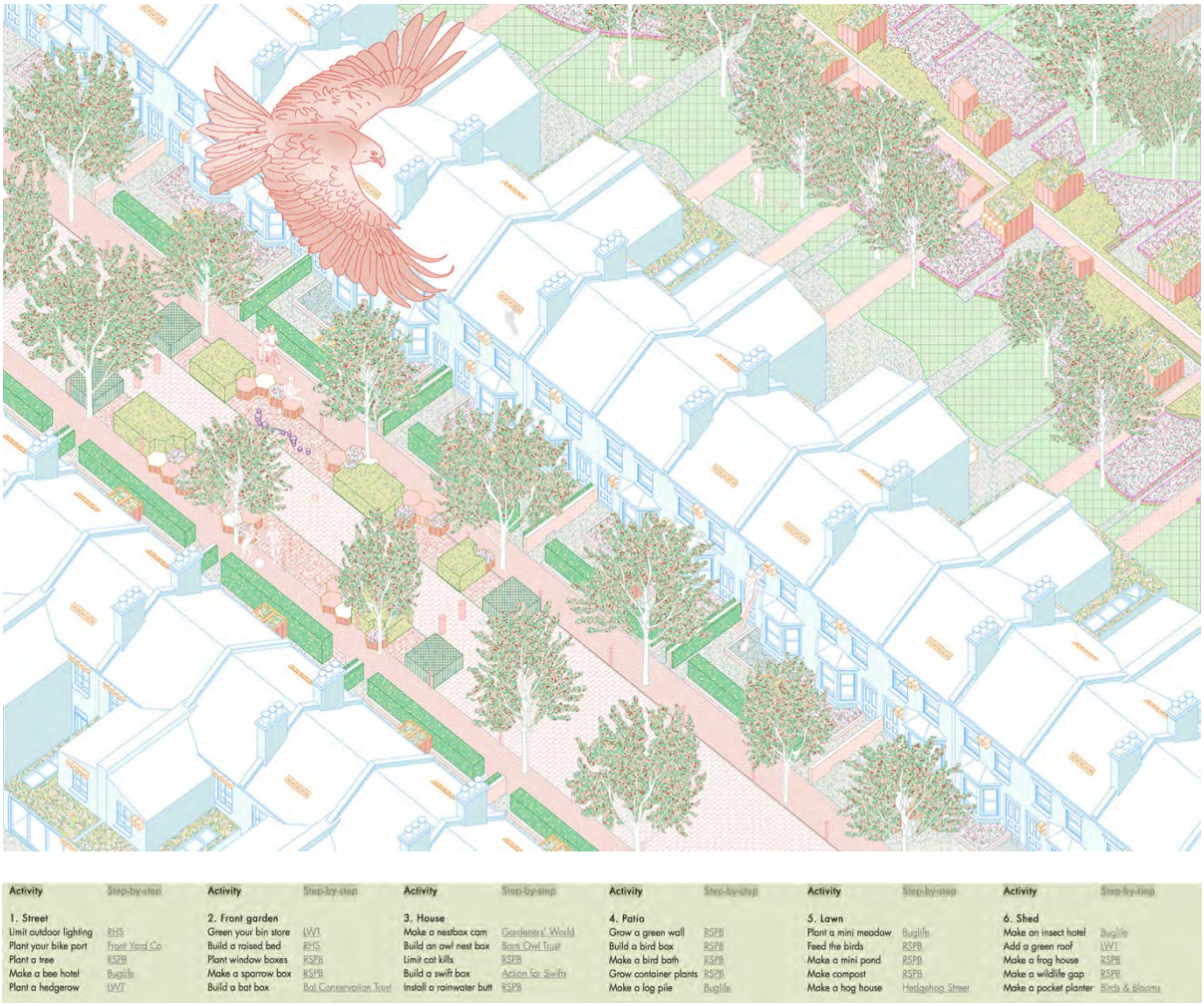
Product	Shop	Product	Shop	Product	Shop	Product	Shop	Product	Shop	Product	Shop
1. Street		2. Front garden		3. House		4. Patio		5. Lawn		6. Shed	
Outdoor lighting	Woodscape	Green roof bin store	Front Yard Company	Nestbox camera	RSPB	Green wall	Freebox	Mini meadow	Meadowmat	Insect hotel	Crocus
Planted bike port	Cyclehoop	Raised bed	Woodblocx	Tawny owl nest box	RSPB	Nest boxes	Habi Sobi	Bird table/feeders	RSPB	Green roof	Posh Shed Company
Tree	Habitat Aid	Window boxes	Crocus	Anti-hunt cat collar	HiCraft	Bird bath	RSPB	Container pond	Waterside Nursery	Frog house	RSPB
Treetop beehive	Bee Kind Hives	Sparrow terrace	NHBS	Swift box	Swift Conservation	Container plants	Crocus	Compost bin	Primrose	Wildlife fence gap	Jacksons Fencing
Hedgerow	Habitat Aid	Bat box/roof tile	NHBS	Rainwater butt	Hugo	Log pile bench	Holmes & Gardens	Hedgehog house	Ark Wildlife	Pocket planter	WallyGro

Figure 6: Back garden elevation showing proposed typical street with adaptations for biodiversity, focusing on products. Source: Siân & Jon Moxon, Viktoria Fenyes.

Finally, the aerial view illustrates home-improvement activities that can be carried out to help wildlife. It shows people participating in some of the activities, such as putting up a bat box or digging a pond, and enjoying the streetscape to give a sense of community. The key references links to step-by-step guides by conservation bodies, which explain how to carry out each activity and which typically list tools, materials, time and budget required.

The design team concluded this drawing portrayed how London's streets could foster a much greater sense of community for those who live there and promote outdoor living for all ages.

The design team was satisfied that the proposals were well considered, the drawings were engaging and the website provided a valuable resource. This has been corroborated by positive reactions to the project from public, professional and academic audiences. The project has been recognised as a winner of the Imagine London as a National Park City competition and finalist of London Metropolitan University's Big Idea Challenge, and has been shortlisted for the Corporation of the City of London's Sustainable City Awards. It is continuing to attract mainstream media coverage, a steady growth in social media followers, mailing list subscribers and support from related organisations. The drawings have been published by the UK's leading architectural trade journal, conservation organisations, and several influential London magazines; and presented at academic conferences and the UK's foremost sustainability trade show.



Activity	Step-by-step
1. Street	
Limit outdoor lighting	RHS
Plant your bike port	Front Yard Co
Plant a tree	RSPB
Make a bee hotel	Buglife
Plant a hedgerow	LWT

Activity	Step-by-step
2. Front garden	
Green your bin store	LWT
Build a raised bed	RHS
Plant window boxes	RSPB
Make a sparrow box	RSPB
Build a bat box	Bat Conservation Trust

Activity	Step-by-step
3. House	
Make a nestbox cam	Gardeners' World
Build an owl nest box	Barn Owl Trust
Limit cat kills	RSPB
Build a swift box	Action for Swifts
Install a rainwater butt	RSPB

Activity	Step-by-step
4. Patio	
Grow a green wall	RSPB
Build a bird box	RSPB
Make a bird bath	RSPB
Grow container plants	RSPB
Make a log pile	Buglife

Activity	Step-by-step
5. Lawn	
Plant a mini meadow	Buglife
Feed the birds	RSPB
Make a mini pond	RSPB
Make compost	RSPB
Make a hog house	Hedgehog Street

Activity	Step-by-step
6. Shed	
Make an insect hotel	Buglife
Add a green roof	LWT
Make a frog house	RSPB
Make a wildlife gap	RSPB
Make a pocket planter	Birds & Blooms

Figure 7: Aerial view showing proposed typical street with adaptations for biodiversity, focusing on activities. Source: Viktoria Fenyes.

A study by Imperial College London MSc students used Rewild My Street as a case study to determine whether people would be prepared to pay for the street improvements shown in the drawings. The study concluded that a significant proportion of the 500 respondents from across Greater London supported paying towards the proposals, highly valuing their potential for wildlife habitat, along with the health benefits of air quality and recreation. Although 82% of those surveyed reported already often seeing wildlife on their streets, over half thought their street needed more greenery; 87% supported implementing some of the proposals.

Reflecting on the primary research question, the above findings suggest that a vision of a rewilded urban street could, in theory, engage residents to adapt their homes for wildlife. In later stages of the project it will be important to assess whether residents are implementing the suggested adaptations in practice.

Considering the research sub-questions, the design process has determined that this vision of living with nature should be communicated through rendered architectural drawings at street scale, a concept collage and a spatial manifesto to inspire the public. Giving the drawings an infographic quality and cross-referencing them to external guidance has helped ensure the vision is also informative to enable residents to carry out the adaptations shown.

Showing the proposals at street scale was essential to help residents appreciate how even small changes they make can contribute to make their overall street a better place for both wildlife and people to live. The plan and aerial view clearly illustrate the sizable habitat area that connected back and front gardens can create. Similarly, the plan, elevations and aerial view show the cumulative greening effect of making changes over the extent of a street.

The literature review and design process revealed that wildlife features should be suitable for small spaces or vertical surfaces, targeted at urban species, and generally of contemporary design and materials to be sensitively integrated within an existing urban context.

Diversity was suggested by showing a large portion of the street, so that a single drawing can at once capture large and small gestures, and a balance between variety and uniformity. This is particularly apparent on the street plan, which shows radical interventions to the streetscape alongside minor changes to the houses and gardens. In addition, indicating stylised habitat zones on this drawing helped show individuality in measures adopted across the street, within a framework of continuity to the street as a whole. Showing off-the-shelf products and DIY activities through separate drawings was judged to be a good way to offer different implementation options in terms of cost and time.

Associating different drawing projections with different topics, and reflecting these in the drawing keys organised by plot zones, was found to be an effective way of organising external guidance and editing it for its relevance to urban contexts.

In summary, the case study has successfully created an inspiring vision of a typical London residential street adapted for biodiversity by applying an architectural design process to produce a set of aspirational drawings embedded in a practical resource. This highlights the potential for design research to promote the ideal of a biodiverse, sustainable city and generate design-led resources to achieve it.

5 Contribution to Field: A Model for Biodiverse Cities

The project makes an important contribution to the field of green infrastructure and biodiversity by addressing gaps in current literature, providing new insights through practice-based design research, and creating a scalable model for future development.

Gaps in existing literature are addressed by focusing on urban rewilding; tackling existing residential contexts; working at street scale; and presenting design guidance for public use.

The use of design research offers particular insights by capturing an inspiring vision of living with nature; creating image-based guidance; efficiently organising information; and ensuring considered integration of wildlife features into a street. There is scope for the project to develop further by the design team being more active in the later project work stages identified in the research methodology. This could include production of technical drawings to further assist with implementation of the proposals; involvement in live prototype projects during construction; and in-use surveys to assess the impact of the measures on biodiversity levels and resident quality of life.

The project resources present a new model, founded on empowering communities to change their living environments by taking more responsibility for their own role in solving environmental problems, both in their immediate environment and globally, in contexts that

are difficult for government to intervene. As such, it shows the way for city dwellers to cultivate and take care of nature on their doorsteps.

The project shows the potential for design research to inspire and empower city residents to change how they live, with designers using their skills to communicate a way to live alongside nature in cities, promoting the potential of urban areas as green, wild and healthy places to live. The resulting output offers a design-led model for encouraging biodiverse redevelopment of London and other cities worldwide for the benefit of wildlife and people alike.

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Designing laughter: Classification and analysis of generation factors of 'laughter' in US-China Sitcom programmes

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Making 'laughter' artificially in the television programme industry will lead to construct the ground of laughter. It might be useful in the television industry to explore the structure of laughter generation factors by choosing up a representative sitcom comedy programme from the two largest linguistic and cultural spheres, the United States and China, because the TV production costs tends to become expensive with costs such as large-scale sets, using foreign locations and computer graphics. In this paper, two popular latest series will be picked up. In addition to the scripts and cultural differences in the sitcom in both countries, combining what kind of conversation and character and looking at by what method laughter would be generated by grasping the essence of the programmes. Sitcom comedy is a relatively simple production method, making everyday conversation to be funny and turning it into a show. I would like to proceed with this research by counting the number of classified factors and comparing the incidence ratios of each item, to clarify the differences in characteristics in programmes of the US and China, from the aspects of industrial structure and linguistic factors of each country. Through this research, the novelty and the high degree of application to sitcoms can be recognised in the classification method presented, and it emerged that laughter was established not only in 'relief of tension' but also in 'from relief to tension' in the sitcom comedy programme. Further, it was discovered that the amount of laughter in the Chinese programme is about half that of the laughter the US programme by linking linguistic features through this research.

Keywords: sitcom comedy , media, classification, TV programme

1 Background and Purpose

The goal of this paper lies in presenting the commonalities and differences between the US and China in sitcom comedy programmes, by classifying and analysing the script with the technique of laughter designing. It might be possible to clarify the difference of laughter due to the distinct linguistic characteristics of English and Chinese, and the difference of social background and to utilise the knowledge gained effectively. The US and China have a strong influence, both as linguistic areas and as television programme production market areas, so it can be expected that the classification and analysis of sitcoms would bring benefits to the television industry. In the US, methods and research to analyse sitcom comedies are made

in such a way that it shows a relation to social background. In China, there are also studies that compare US and Chinese programmes. From reviewing these studies, it could be said that sitcom programmes in the US and China have already taken root as research subjects. According to Berger's (1993) classification and other previous theories on humour, there remain elements that could not be explained about the laughter that occurs in the sitcom comedy programmes, and I thought it could be identified by performing text analysis of major programmes of the US and China in detail. Also, from the study of Amemiya (2016) and Ong (1982), it is assumed that laughter in sitcom comedy is also affected by linguistic characteristics and the industrial structure of the television industry. By analysing the programmes, it is considered that the difference in how to make laughter due to the difference in each language sphere can be extracted.

The influential TV sitcom Big Bang Theory in the United States is still being broadcast (even in 2019). Aiqing Gongyu (爱情公寓) has been broadcast over the long term throughout China. Analysing representative programmes and categorising the process of ‘laughter’ inductively in the U.S and China could be meaningful to the TV industry.

2 Literature Review

Berger (1992) analyses humour techniques in various media and classifies them into 45 types. There are (a) three types of actions (physical and non-verbal humour), (b) 14 types of natures (existential humour), (c) 13 kinds of logics (humour assembled in idea) and (d) 15 kinds of languages (humour of language).

Ong (1982) classified languages as ‘primary orality’ and ‘secondary orality’ and analysed transmissibility, ‘primary orality’ is a character based on words as voices who do not know anything about writing or printing things, and the character of ‘secondary orality’ can be transmitted by documents that can be passed down in writing.

Amemiya (2016) extended Ong's discourse and noted that in Western Europe, people are using phonograms and there are also premises that even intellectual documents are read aloud, Japanese language is having most complex notation system in the world using three kinds of letters, the correspondence between letters and sounds is extremely weak. The intellectual discourse stops in the category of written letters since Buddhist scriptures and Chinese classics. They weren’t expanded as culture of voice. Also, several mainstream theories exist as a prior study for interpreting humour and laughter. The theories to analyse the mechanism of laughter, by philosophers such as Kant and Schopenhauer, have been constructed and built on the basis of the academic fields of philosophy and psychology. When humour analysis is limited to ‘analysis of comedy programme’, the concepts of ‘superiority theory’, ‘energy theory’ and ‘incongruity theory’ can be adopted as a rough classification. Furthermore, in addition to those theories, it might be useful to use ‘relevance theory’ of the linguistics field, as a method in the sitcom comedy programme based on ‘multiplication of communication words’. Combining these four theories makes it possible to analyse the method of designing laughter in comedy programmes from a wide range of approaches.

On the other hand, if the above four theories are applied to the analysis of comedy programs, the three kinds of humour theory can, basically, analyse laughter which occurs in the structure of ‘one (person) to one’ and ‘one to the public’. But it could not cover the analysis of laughter which occurs in the structure of ‘programme producer to programme viewer’. Although ‘relevance theory’ also explains the laughter caused by the misalignment that

occurs in parts, there remains a point that could not be explained with respect to the laughter that occurs in the programme.
The article by Takagi (2018) analysed the laugh of the U.S programme (I love Lucy: 1951-1957) and discussed the ‘handcuffs gag’ in the 1950s, but she mainly focussed on ‘action’ that forms a comedy, she did not mention linguistic isshues and research on current social background so much. Nakamura's (2018) paper analyses the mechanism of the brain that recognises laughter (especially ‘incongruity’), but did not cover the mechanism affecting TV viewers of comedy programmes. Therefore, while starting from the four theories, this paper adds a new viewpoint useful for the analysis of sitcom comedy programmes and the analysis of sitcoms and the development of comedy programmes.

3 Research methods

As a research method, the process is as follows: (1) Writing a programme script of Big Bang Theory in the U.S and Aiqing Gongyu in China. (2) Creating scripts in English and Chinese. (3) Recording the occurrence of ‘laughter’ (laugh track) together with the time code. (4) Recording the video effects such as ‘slow motion’, ‘pan up’ edits in the programme. (5) Based on the previous research and creating the item description of laughter, classifying factors of laughter of each place. Classification is arranged by major classification, small classification and hierarchy. (6) Counting the number of classified factors and comparing the incidence ratios of each item, to clarify the differences in characteristics in programmes of the US and China, from the aspects of industrial structure and linguistic factors of each country. (7) Analysing laughter in sitcom comedies from multiple angles. (8) Presenting the commonality and difference between US and Chinese programmes on laughter designing.

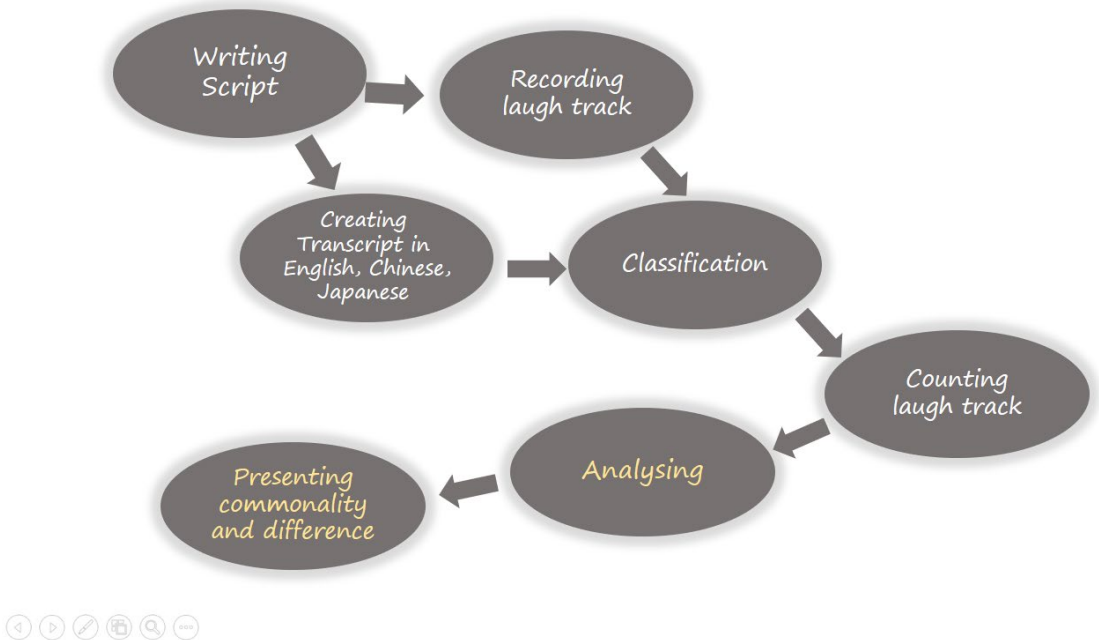

Figure1. Research methods

The transcription of Big Bang Theory includes Episode 1(22 minutes and 22 seconds), Episode 2 (20 minutes and 35 seconds), from Season 1; Aiqing Gongyu uses Episode 1 of Season 1 (43 minutes 34 seconds). Big Bang Theory adds English script and Japanese translation (by using hulu internet platform). In Aiqing Gongyu, this research will prepare the Chinese script (through the youtube platform) and Japanese translation (my own work) as necessary.

4 Research Context and Process

4.1 Classification of causes of sitcom comedy programme laughter

In addition to examining the four theories, this research has written a script of each programme in the US and China and analysed the cause of laughter. As a premise of the preliminary stage of classification, the laughter of comedy programmes might be considered to be caused by factors at 'setting level', 'linguistic level' and 'behaviour level'. These three levels are derived as a result of structurally watching comedy programs and movies laughing and analyzing the past Burger's analysis of laughing, and it is considered to be almost complete coverage.

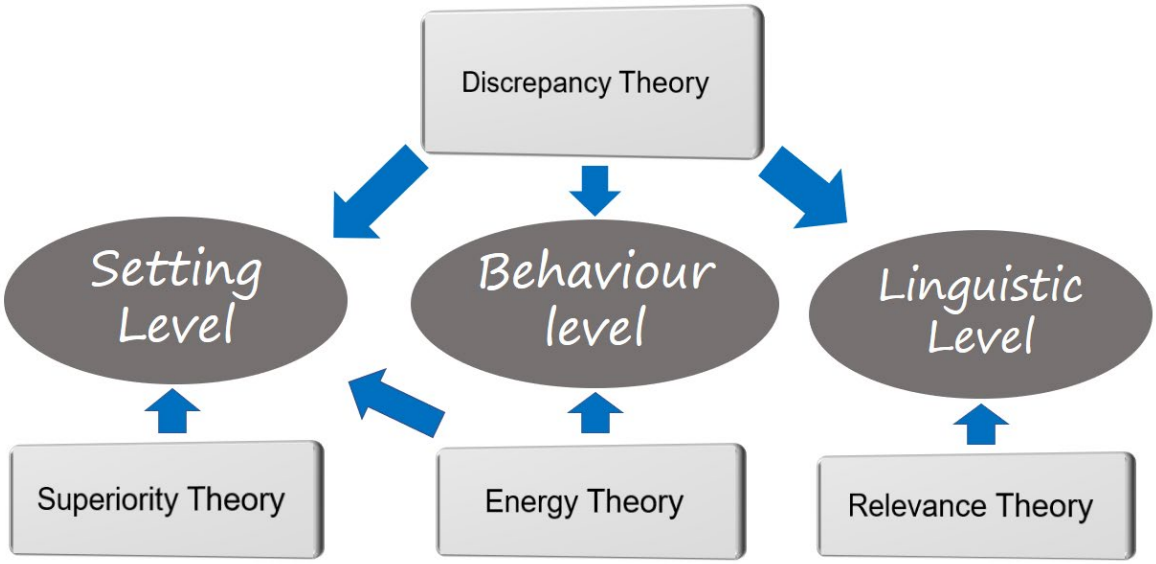

Figure2. The relevance between 'three levels' and 'previous four theories'

4.2 Examination of Language, Setting, and Behaviour factors

'Setting level' is what makes laughter as 'setting' of characters and scenarios. It depends on situations, and also on the composition of the world view of the programmes and composition. 'Language level' refers to laughter which is borne out of conversation among characters. It is a laugh made by a combination of words. 'Relevance theory' can be applied to this language level laughter. Laughter at the 'behaviour level' refers to laughter which is borne out of the character's 'funniness of movement'. *Charlie Chaplin* (products: 1914-1967), *Buster Keaton* (products: 1917-1967) in the silent movie era are remarkable examples. In addition to the setting level, the prominent comedy in Britain the UK, *Mr. Bean* (TV series:

1990-1995) also has laughter in Bean's behaviour itself. Each level is difficult to completely separate, and there are scenes where there are mixed levels.

4.3 Major classification of generation factors

As a result of analysing prior research on scripts and humour of both sitcom programmes and focusing on factors such as setting, language and behaviour, the following classification could be shown. By that research and my point of view, (A) - (H) will be presented as a major classification.

(A) Incongruity. It is an action which is out of character for an adult, behaving childlishly and mistakes caused by immaturity as a human being. (B) Mixture of real and imaginary things. True build-up based on fictions such as delusions, fantasies, assumptions. Fictions piled upon fictions on the premise of reality. (C) Energy Transferring. From tension to relief and from relief to tension. Energy transferring 'from tension to relief' is a general direction in energy theory. But the direction 'from relief to tension' such as 'situation into awkward silence', 'situation into police matter', 'situation into food allergy' 'situation into loss of expensive things' also leads to generate laughter at sitcoms. (D) Discrepancy between implicature and explicature. Misinterpretation between the speaker and the listener. (E) Sound factors. Linguistics, phonology, higher and lower voice. (F) Recognition of congenital differences, attribute differences. (G) Change in framing. Things that make viewers laugh by changing the view and angle of things. (H) Others.

4.4 Small classification of generation factors

I have classified the major classifications (A) - (H) more inductively while viewing each programme and examining factors of laughter designing. The classified factors are listed below.

Table1. Small classification of generation factors

A	A1	Gullibility
	A2	Missing ability to read the mood
Incongruity	A3	Innocent abnormality
	A4	Reckless to say easily that it can't be impossible
	A5	Strange commitment of specific characters
	A6	Betrayal of promises
	A7	Evoking jealousy
	A8	Loudly speaks without caring about surroundings
	A9	Concentrating something with enthusiasm
	A10	Strange clothes
	A11	Behavior in inappropriate time zone
	A12	Stingy behaviors
	A13	Brainless
	A14	Acting fast or slowly, repeating longly
	A15	Declaring with confidence, but wrong guessing
	A16	Horny. Dirty joke.
	A17	Mistake, acceptance of mistake
	A18	Lack of flexibility

B Mixture of real and imaginary things	B1a	Speech for something that is regarded as justice for the general public
	B1b	Insertion of real things into conversation
	B2	Contradiction
	B3	Exaggeration
	B4	Logic to justify strange commitment
	B5	Serious discussion on fiction
	B6	Complex explanation derived from new knowledge
	B7	As a result it was a dream
	B8	Seriously receiving lies
	B9	Laying a lie
	B10	Lie is revealed

C Energy Transferring	C1	Accidentally wig come off
	C2	Attitude change
	C3	Change of appearance on drinking alcohol
	C4	Failure of trick
	C5	Strange behavior
	C6	Awkward for no reason
	C7	Deformation of face from food allergy
	C8	Lost expensive items
	C9	Situation into police matter
	C10	Unexpectedly serious, tragedy, furious. Unexpected reaction
	C11	Abbreviation of process

D Discrepancy between implicature and explicature	D1	Misunderstanding
	D2	Extended interpretation
	D3	Boasting
	D4	Militant question
	D5	Answer with high versatility
	D6	Unnatural metaphor, unnatural illustration
	D7	Originally should be Interpreted through implicature, but though explicature
	D8	Explicature is ordinary, but guess is dirty
	D9	The difference between true intention and public stance
	D10	Roundabout rephrasing
	D11	Pointing out strange reality, pointing out mistakes
	D12	Detour

E Sound factors	E1	Rhyming
	E2	Tongue twister
	E3	Homonyms, mistakes with similar sounds
	E4	Impersonation
	E5	Higher and lower voice
	E6	Impact of word itself

F	F1	Ethnic
	F2	Disabled person, sick
Recognition of congenital differences, attribute differences	F3	Not understanding own culture or other cultures

G	G1	Unexpected event against arrangement
	G2	Strange, abrupt behaviour at the beginning of the scene
Change in framing	G3	Abrupt topics, abrupt remarks, abrupt turning
	G4	Reversal of position

H	H1	Demonstrated from performance
	H2	Visual effect
others		

(A) Incongruity. This is related to mismatch and classified into 18 items from A1 to A18, such as gullibility, missing ability to read the mood, innocent abnormality. This item is mainly affected by 'discrepancy theory'. Hurley (2011) showed energy theory, discrepancy theory and superiority theory.
(B) Mixture of real and imaginary things. This item occurs in 'between reality and fiction' and was classified as B1 to B10 such as contradiction, exaggeration, logic to justify strange commitment.
(C) Energy Transferring. This item occurs in 'energy transfer' and was classified from C1 to C11 such as attitude change, awkward for no reason, unexpectedly serious. Energy theory is explained by the concept of 'release of nervous energy (release theory)' 'release of nervous excitement' and 'tension and relaxation'. Nakamura (2017) pointed out the importance of the energy theory factor (Spencer, 1859; Freud, 1905), the release of surplus nervous energy.
(D) Discrepancy between implicature and explicature. This item could be classified from D1 to D12 such as militant question, answer with high versatility and unnatural metaphor. The relevance theory has been conducted mainly by Sperber and Wilson (1986, 1995).
(E) Sound factors. This item was classified from E1 to E6 such as rhyming, tongue twister, homonyms, impersonation, higher and lower voice. Elements of sounds are also usually caused by deviations from the speed at which people talk.
(F) Recognition of congenital differences, attribute differences. (F) was classified from F1 to F3 such as ethnic, disabled and not understanding own culture. This item can be argued from 'superiority theory'. Superiority theory is that when people recognise and point out 'superiority' over others, laughter is born.
(G) Change in framing. This item was classified from G1 to G4 such as unexpected event against arrangement, strange behaviour at the beginning of the scene, abrupt topics and reversal of position. This item also involves the discrepancy theory.
(H) Others.This item was classified from H1 to H2 such as the factor demonstrated from performance, visual effect.

4.5 Application of each work to small classification

Through applying the scene of programme to these factors, the reason of 'how to make laughter', 'the commonality of method in two countries', 'the difference of each country's tendency' could be recognised. When this research applies classification to the programmes,

there are places where it is considered that laughter is occurring with a mixture of multiple factors. In that case, a factor that can be judged to be stronger is applied.
As a result, in terms of the percentage in the US and Chinese programs, there was a trend difference in the factors of laughter occurrence (Table 2). In common both US and Chinese programmes, D11 'pointing out strange reality, pointing out mistakes' is more than 10%, the most cause of laughter is D10 'roundabout rephrasing' which also occupies a relatively high proportion in both the US and Chinese programmes.
Concerning the factor of generating laughter, the top items of the US work and the top items of the Chinese work are shown in Table 2.

Table2. Descending order the factors of laughter occurrence on each programme (U.S, China)

US	China
D11 : Pointing out strange reality, pointing out mistakes (15.2%) 42	D11 : Pointing out strange reality, pointing out mistakes (12.6%) 21
D10 : Roundabout rephrasing (9.4%) 26	C10 : Unexpectedly serious, tragedy, furious (7.8%) 13
B5 : Serious discussion on fiction (6.5%) 18	B3 : Exaggeration (7.8%) 13
A5 : Strange commitment of specific characters (6.1%) 17	G1 : Unexpected event against arrangement (7.8%) 13
A2 : Missing ability to read the air (5.1%) 14	A13 : Brainless, poor common sense (7.2%) 12
D9 : The difference between true intention and public stance (5.1%) 14	D10 : Roundabout rephrasing (4.8%) 8
C6 : Awkward for no reason (4.7%) 13	G2 : Strange, abrupt behaviour at the beginning of the scene (4.8%) 8
A17 : Mistake, acceptance of mistake (4.3%) 12	D6 : Unnatural metaphor, unnatural illustration (4.8%) 8
B4 : Logic to justify strange commitment (4.0%) 11	C2 : Attitude change (4.8%) 8
B6 : Complex explanation derived from new knowledge (4.0%) 11	A12 : Stingy behaviours (4.8%) 8

4.5.1 Commonality of two countries

D11 is one in which one of the performers makes a descriptive mention about some sort of 'funny thing' happening. 'To recognise funny things' also includes elements of disagreement. On the other hand, there is some kind of transmission intention and relevance to the act of the characters describing a funny situation and telling others to inform them. So, these cases are categorised into D. D10 is a roundabout paraphrasing, it brings about a low relevance that does not convey to the listener smoothly. This also has the effect of causing the viewers to 'the viewers view it with sarcasm'.

4.5.2 Difference of each country

Other than the commonality, the elements in B5, A4, A2 are among the top items in US programmes, and the elements in C10, B3, B1 are among the top items in Chinese programmes.

5 Specific analysis of cases

From the script of the transcribed work and the content of the programmes, This paper will analyse concrete examples of factors that occur frequently.

5.1 Application of each work to small classification

5.1.1 Consideration of the case of commonalityof two countries

This research will focus D11 case from *Big Bang Theory* as a 'commonality of two countries'

US case analysis

Big Bang Theory 1-2 2: 22-

Sheldon: I have a very wide circle. (1) I have 212 friends on myspace. (2)
Leonard: Yes, and you've never met one of them.(3)

In this conversation, laughter occurs in three places (1)-(3).

(1) B3 'Exaggeration'
(2) D6 'Unnatural metaphor, unnatural illustration'
(3) D11 'Pointing out strange reality, pointing out mistakes'

(1) is not like wide, but laughter is born in Sheldon who exaggerates it. In (2), to show the extent of friendship relations, 'laughter' is born with 'unnaturalness' indicating the number of 'friends on SNS'. In (3), Laughter is raised by pointing out from the script of '*You never met one of them*', viewers can realise 'the absence of Sheldon's friendship relationship' again.

China case analysis

Aiqing Gongyu 1-1 4: 22-

In the apartment, Meijia (woman) and Xiaoxian face for the first time. A scene where Meijia asked Xiaoxian.

美嘉：请问你是街道办事处下属公寓住户委员会妇女主席吗？(1)
Meijia: Are you the woman president of the condominium housing committee in the district office?
小贤：副主席。(2)
Xiaoxian: Vice-president

(1) E3 'Homonyms, mistakes with similar sounds'
(2) D11 'Pointing out strange reality, pointing out mistakes'

(1) Laughter occurs when Meijia obviously knows that he is a male, listening to '*Are you the woman president*?" Although this part includes elements of A13, it is more reasonable to interpret the utterance mistake as a result of the similarity of pronunciation of 'woman president (Chinese pronunciation: *Fùnǚ zhǔxí*)' and 'vice-president (Chinese pronunciation: *Fù zhǔxí*)'. Even though this mistake alone makes laughter by mistake of Meijia, laughter can be reconstructed as (2) by Xiaoxian uttered with '*Fù zhǔxí*' with a strong tone and corrected.

5.1.2 Focusing the feature of US: A consideration on a 'serious discussion on fiction' B5

B5 'serious discussion on fiction' is a factor mostly found especially in American products.

Big Bang Theory 1-2 2: 22-
A scene in which all the characters gather and talk in front of the elevator. Leonard told Penny, the topic of the movie *Spider-man*, and Penny mentioned the scene '*Spider-man* took Royce in the air', Sheldon joined.

Sheldon: You realise that scene was rife with scientific inaccuracy.(1)
Penny: Yes, I know, men can't fly.
Sheldon: Oh no, let's assume that they can.(2) Lois Lane is falling, accelerating at an initial rate of 32 feet per second. Superman swoops down to save her by reaching out two arms of steel. (3) Miss Lane, who is now travelling at approximately 120 miles per hour, hits them and is immediately sliced into three equal pieces. (4)

(1) B5 'serious discussion on fiction'
(2) B2 'contradiction'
(3) B5 'serious discussion on fiction'
(4) B6 'complex explanation derived from new knowledge'

(1) makes laughter from the factor of B5 'serious discussion on fiction'. Sheldon inconsistently puts scientific knowledge into the fictional world *Spider-man*. B2 'contradiction' has arisen on (2). Sheldon said 'scientifically impossible' reverting fiction into reality, and denied 'assumption', but he said '*let's assume that they can fly*', accepted the setting of 'assumption'. The laughter of (3) occurs in childishness that seriously discusses fiction by adding notions such as per second and speed based on precise calculation. (4) adopted B6 'complex explanation derived from new knowledge'. New knowledge means the knowledge of a new concept that seems to be 'indeed' for viewers. This block can be said to be the highlight of the *Big Bang Theory by* mixing B2, B5 and B6 into one block.

5.1.3 Focusing the feature of China: A consideration on 'exaggeration' B3

Resulting from investigation, I could point what is widely used in China is B3"exaggeration". I would like to indicate concrete script from *Aiqing Gongyu*.

Aiqing Gongyu 1-1 4: 22-
In the living room, Yifei and Ziqiao, Xiaoxian talked about going to dinner, and at the same time Wanyu and Zhanbo came into the room as if he had listened to them next door.

婉瑜：谁叫我，谁叫我(1)
Wanyu: Who called me? Who called me? (1)
一菲：哇，你耳朵这么灵啊
Yifei: Wow, you have sharp ears.
展博：是鼻子灵，婉瑜说她问到了、大餐的味道(2)
Zhanbo: It is the nose spirit, Wanyu said that she sniffed the taste of the big meal. (2)
子乔（本心）：妈呀，这么多张嘴，一剑杀了我吧(3)
Zi Qiao (inner heart): Oh my god, so many mouths will kill me. (3)

(1) G1 'unexpected event against arrangement'
(2) D10 'roundabout rephrasing'
(3) B3 'exaggeration'

Laughter of (1) is occurring in the unexpected development that they entered the room with good timing as if they were hearing it. Laughter of (2) occurs by D10 'roundabout rephrasing'. It was the timing of two people entering the room to listen to the story, while Yifei admired that 'I heard ear', while Zhanbo said 'Her nose was working to luxury food'. The laughter of (3) originated from Ziqiao's exaggerated expression, which was originally thought to be a treat for only Xiaoxian. As a result, Ziqiao found he would have to increase

the number of people who have to feast, and disappointed, said exaggeratedly ‘many mouths will kill me’.

6 Findings

The new discovery and viewpoint obtained in this research can be said to be the following three items.

1. In conventional research, it was difficult to classify the laughter of sitcom comedy programmes in concrete forms. The novelty and the high degree of application to sitcoms can be recognised in the classification method presented in this research. It was possible to classify all of the laughter in the US sitcom Big Bang Theory (on 1-1, 1-2) and China’s Aiqing Gongyu (1-1).

2. In the conventional humour analysis, the occurrence of laughter in the flow of tension to relief has been presented using ‘energy theory’. In Martin and Ford’s (2018) paper on the analysis of humour, although they use ‘relief of tension’, they never mention ‘from relief to tension’ as vector in the opposite direction. Hurley (2011) also described ‘In general, release theories claim the tension from thought can build up, and when this tension released by a positive emotion that results from further thought, the energy is transformed into (or spent by) laughing’. In the sitcom comedy programme, in both the US and China, it emerged that laughter was established not only in ‘relief of tension’ but also in ‘from relief (relax) to tension’ in energy theory.

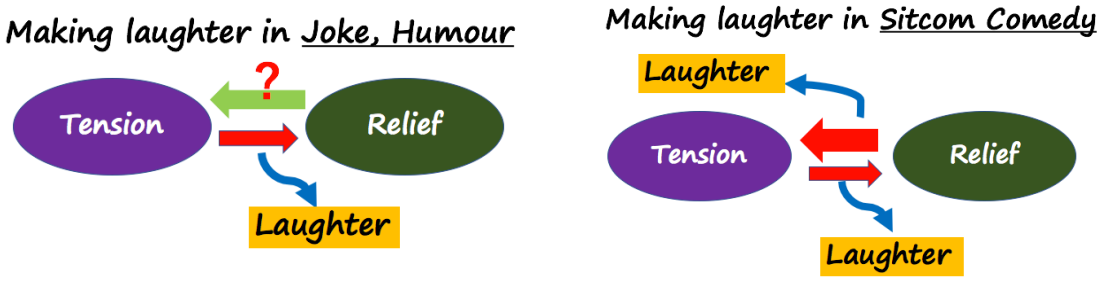

Figure3. Comparing ‘making laughter in joke, humour’ with ‘making laughter in sitcom comedy’

3. When converting to the same time, the amount of laughter in the Chinese programme is about half that of the laughter the US programme. This is also related to the linguistic characteristics. In conveying Chinese language and humour, there is usually a time lag in understanding related to the visual elements in TV programmes, so the number of laughs in a Chinese programme can be taken to be fewer than in an English language programme.

7 Conclusions

Through this research, it transpired that the most laughter was borne out of the act of ‘pointing out mistakes’ and ‘pointing out strange reality’ in sitcom comedy programmes. The method of designing laughter in English-speaking countries and Chinese-speaking countries also influences linguistic characteristics. ‘The difference between true intention and public stance’ is a sarcastic effect that skilfully uses the relevance of words in communication.

In the US programmes, a theoretical construction using fiction and reality can be seen. In Chinese programmes, a lot of laughter building from homonyms, exaggeration and setting

levels is done relatively. This tendency comes from the utterance system of Chinese expressing by using tone (four tones). Chinese language is spoken by the magnitude, the high and low of the sound, and is thought to be due to features such as making a metaphor on exaggeration, including impossible assumption into conversation. In Chinese programmes, there is a tendency to produce laughter due to structural changes rather than the magnitude of relevance.

As a result of classification, it was found that the laughter occurrence of the US programme is about twice as fast as that of the Chinese programme. When the viewers 'listened' to the story, it is easy to understand the phonetic character 'English' is 'what you are saying'. On the other hand, Chinese words as an ideogram are many homonyms, so it can be considered that Chinese language is harder to judge instantaneously than English language. Watching from industry structure, in China, basically-recorded programmes are supplemented with subtitles at the bottom of the screen. It has been thought of to compensate for difficulty in understanding due to bias in pronunciation in each region by appending the unified notation of Chinese character.

Because the sitcom format is based on the humorous combination of words, there occurs a time lag of understanding in Chinese language, so there is a tendency to make heavy use of 'unexpectedly serious, tragedy, furious, unexpected reaction, result' and 'unexpected event against arrangement' than multiplication of words.

8 Implications and Future Research

Future tasks include the need for concrete analysis using more programme examples. In addition to items detailed in the classification presented in this paper, more concrete analysis can be done. Further cases, other sitcom comedy programmes in the US and China, or programmes excluding the US and China could also be used to explore the designing laughter of programmes in various languages and cultures.

Categorised items can also be seen to function as premises from the factors. There is room for improvement in accuracy such as 'medium classification', which is setting intermediate classification between large classification and small classification, or upgrading small classification to medium classification and setting new subclasses. This research will contribute to the ability to design scripts more mechanically in Sitcom programs in the future.

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Erglove: a wearable ergonomic solution for wrist injury prevention

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Hotel house cleaners are at high risk for musculoskeletal disorders due to strenuous and repetitive tasks: in particular, wrist injury is prevalent due to many combined hours of wiping in inappropriate postures. Erglove is an instant and long-term wrist posture feedback system that allows cleaners to gain awareness of their posture and change their behaviour as they wipe. An exploratory user study was conducted to compare the effects of using the Erglove feedback system versus no feedback on the wiping behaviour of a group of college-age participants. The results indicated that the perceived system usefulness was higher in the group with real-time feedback. The study findings provide initial insights into how design can influence usage behaviour in the context of posture improvement. These insights likely extend beyond the specific application to wrist MSDs prevention for hotel housecleaners and are applicable to a wide variety of everyday tasks.

Keywords: Hotel Cleaners; Musculoskeletal Disorders; Ergonomics; Wearable Computing

1 Introduction

The hotel industry is one of the largest workforce sectors in the United States, with 163,000 employees predicted to be working in this field by 2024 (Bureau of Labor Statistics, 2015). The incidence rate of nonfatal occupational injuries for the hotel sector was 4.5 per 100 workers in 2017, in comparison to 3.1 per 100 workers in across all industries (Bureau of Labor Statistics, 2017). In a 3-year cohort study of hotel workers, the average rate of injury was 5.2 injuries per 100 person-years and housekeepers had the highest rate of injury amongst the jobs surveyed, with an injury rate of 7.9 per 100 person-years, as well as the highest rate of musculoskeletal disorders - 3.16, in comparison to 2.0 for the average of all jobs (Buchanan et al., 2010). Another study of 258 hotel housekeepers in San Francisco reported that 75% of housekeepers experienced work related pain, 73% had to visit a physician due to severe pain, and 53% had to take time off work to recover (Lee & Krause, 2002).

These statistics highlights the significant risk of work-related injury among housekeepers. These injuries are considered musculoskeletal disorders (MSDs), and occur when a worker's physical task is too strenuous or too repetitive. Housekeeping jobs involve many repetitive and strenuous tasks, including bed-making, vacuuming, item organizing, and wiping a

variety of surfaces. These tasks often involve high force exertion, repetitive actions, standing for long periods, and lack of physical recovery time, leading to ergonomic risks and potential MSDs.

Repetitive cleaning using a sponge or a cloth is an example of such a task, which can lead to potential MSDs that are commonly performed by housekeepers. The European Agency for Safety and Health (Tim Tregenza, 2009) identified this task as moderate risk. The exertion for this task is exacerbated by the rise in chrome surfaces, large mirrors and floor to ceiling windows in hotels (Hedge, 2016). Several studies have demonstrated the negative impact the task of cleaning poses on workers. For instance, in a study comparing cleaners versus non-cleaners, researchers found that cleaners had poor electrophysiological function in their median nerve (which runs through the arm and wrist), indicating intrinsic nerve damage (Pierre-Jerome, Bekkelund, Mellgren, & Torbergsen, 1996). Median nerve damage can lead to serious disorders such as carpal tunnel syndrome (Upton & Mccomas, 1973). Moreover, in another study comparing workers performing vacuuming versus toilet cleaning tasks, cleaning toilets was identified as a task that required immediate intervention (Weigall, Simpson, Bell, & Kemp, 2005). These studies suggest that the task of wiping (i.e. cleaning using a sponge or cloth) poses great strain on the wrists, making this articulation a potential place for injury among workers in hotels.

Currently, to our knowledge, while there is no tool developed with explicit intention to support a user's posture when wiping, there are a few product options that decrease the ergonomic burden of cleaning. For example, the SakSak wiping glove, which is covered in small bristles, allows the user to combine the action of wiping with scrubbing. However, this glove is designed for dishwashing and would not be useful for wiping large wide areas such as windows due to its small surface area. In this particular aspect, the Duop (Clean Design Company LLC, 2017) wiping tool seems a better wiping tool option: it features a wide, flat square for wiping large surfaces connected to a ball shaped grip, resulting in an bigger wiping surface area compared to SakSak. Still, the greater the area the greater the effort made by the workers. The Duop may improve efficiency but not necessarily ergonomic posture. Lastly, the market offers robotic window cleaner, which drives around the window surface removing dirt, eliminating all ergonomic burden from workers. However, this approach is not feasible for most hotels due to purchase and maintenance cost. Although the aforementioned tools improve the workers' task of wiping, they are limited in raising workers' postural awareness and stimulating them to change their postures. A good wiping tool could still cause physical burden if workers are not assisted to consciously operate them. The Delta 1 (Iterate Labs Inc, 2019) created by Iterate Labs is a wrist motion and position-tracking tool designed to assess risk of developing MSDs. This product shows promise, however it appears to focus on data tracking rather than providing feedback focussed on informing hotel workers on their specific ergonomic risks.

To mitigate this issue, this paper proposes Erglove: a wearable product that informs hotel housekeepers about the ergonomic risks resulted from improper wrist posture while wiping. Erglove also aims to encourage workers to change their behaviour, protecting against median nerve damage or other wrist MSDs. In the following sections, we will introduce our design process followed by a preliminary user study, and illustrate a functional prototype.

2 Conceptual Design Process

Our main design goal was to provide feedback for hotel cleaners so that they could improve their wrist posture. In practical terms, our design consists of a glove embedded with flex sensors, a micro-computer, and sewn-in LED lights. The flex sensors would collect movement input from the worker using the glove; the LED lights would inform the workers about their wrist posture.

To better inform our design, we conducted an expert interview at a hotel where we learned more about the concerns of housekeepers. We observed some of the staff as they cleaned a room and asked them a series of questions about their work schedules, tasks, training, as well as worker demographics and most common difficulties. Based on this interview, we found four major design concerns: flexibility, waterproofness, social acceptability, and privacy of feedback. Equipment flexibility is crucial for hotel cleaners since they have to perform many micro-tasks with the same tool. Good equipment should not hinder workers movement when carrying out these various tasks. Waterproofness is essential for the system to be applied in the real world. Cleaners need to use water and other liquid detergents during their work and the system will inevitably contact them. Lastly, we brought to the interview the idea of a product that reads a user's behaviour and provides feedback on the behaviour. We explained that such product would collect data; in concordance with our initial view, the workers shared concern with privacy. We considered these four major concerns in conceptualizing our design.

It is worth making one particular observation regarding the expert interview and our system's feedback function. Although most of approaches to designing for behaviour change suggest giving users real-time feedback as a means of increasing their awareness (e.g., Niedderer et al., 2014; Wende, 2013), our participants expressed contrasting opinions. The hotel cleaners we spoke were not enthusiastic about real-time feedback. To better understand the usefulness of real-time feedback, we conducted an exploratory user study that tested how cleaners would respond to real-time wrist feedback, which is described in the following section.

Figure 1. Photos of existing tools used by hotel cleaners

3 User Study

3.1 Participants

We conducted a preliminary study with a convenience sample of four college students. The study was anonymous and no demographic information was collected.

3.2 Study setup

The study focused on assessing the effectiveness of different types of feedback on participants' experience and perception of our design. One of our success criteria was an improvement in wrist posture between the first and second round of cleaning. We counted the number of wrist posture mistakes made while cleaning. The other criterion was a positive perception towards Erglove. This was measured through a post session survey. There were two conditions in our study: one group performed the task using our glove with real-time feedback, plus post task feedback; the second group performed the same task using our glove, but with post task feedback only. We instead used Wizard of Oz technique (Buxton, 2010). We observed participants during their task performance instead of using flex sensors. Also, we gave feedback using a remote-controlled light.

3.3 Procedure

Each session of our study consisted of four phases:

1. Introduction: Participants were read a verbal consent statement followed by a brief explanation of the study procedure. Participants were introduced to the tasks they needed to complete, the setup, and the cleaning tools they would use. Participants then had the opportunity to get acquainted with the cleaning tools.
2. Cleaning 1: In order to gauge participant motivation, participants were asked to set a goal for how well they wanted to clean on a Likert scale (very well, well, average, poorly, very poorly). Participants were then asked to clean the first window.
3. Cleaning 2: After completing the first cleaning, researchers told the participants how many mistakes they made. Participants were then asked to set a goal for how much they wanted to improve on a scale of 10% to 50%. Participants were then asked to clean the second window.
4. Survey: After cleaning the second window, participants were given a survey asking 3 positively worded questions and 3 negatively worded questions. They were asked to respond via a Likert scale of strongly agree, agree, neutral, disagree, strongly disagree.

Figure 2 illustrates our study set up. Participants were asked to wear arthritis compression gloves to simulate our product and were given a Swiffer and glass cleaner to clean food colour off of windows. LED lights were mounted in the corner of both windows and were activated for the experimental group. A facilitator of the study observed and counted the number of mistakes for both groups and manually triggered a LED light for the experimental group (i.e., participants with real-time and post task feedback). Mistakes were determined by wrist deflection of more than fifteen degrees in any direction. The facilitator judged this deflection visually. Real-time feedback was delivered in the form of a colour changing LED light. The LED light was lit green when a participant's wrist posture was correct, and the LED light was turned red whenever a participant's wrist deviated significantly from good posture. The control group was given no real-time feedback while cleaning. Both groups were told how many mistakes they made during each round of cleaning and both groups were asked to complete the same post-session survey.

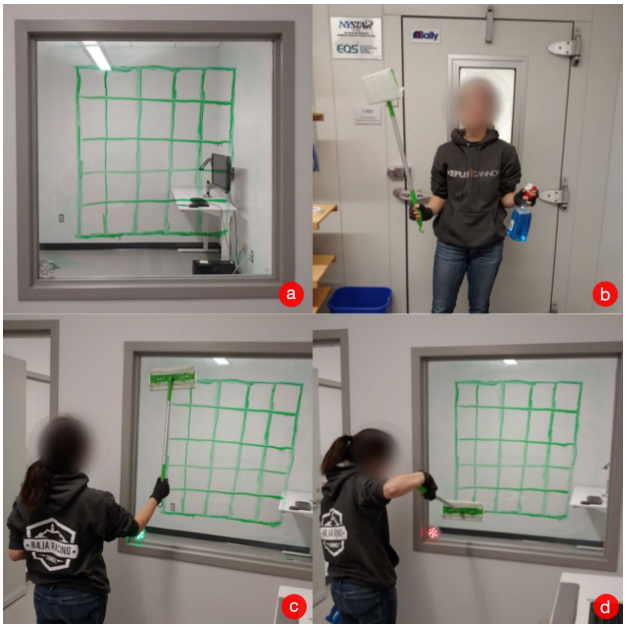

Figure 2. Study set-up. a) food coloured pattern on a window b) a researcher holding cleaning implement and cleaning spray c) green light when wrist posture is good d) red light when wrist posture is bad.

3.4 Results

Table 1 shows the questions and average responses from the post session survey. The survey results show a difference between the experimental group and the control group's perception of our design and feedback system. The experimental group was more positive about the feedback and the system as a whole compared to the control group. Not enough participants participated to allow for any statistical analysis to be done with the data beyond recognizing the aforementioned differences between the groups.

Table 1. Average user response to post session survey: scoring of 1-5 on a Likert Scale with 1 corresponding to strongly disagree and 5 to strongly agree.

Statement	Average User Score	
	Experimental	Control
I think this glove is comfortable	2.0	4.0
I do NOT want to wear this glove	4.0	2.5
I want to use this sweeper	3.0	2.0
I think the feedback is POINTLESS	1.5	4.0
The system is NOT going to change my behaviour.	2.0	3.0
I feel like the system will protect me from injury	3.5	2.0

Participants were generally interested in performing well and also sought to make a small to moderate improvement in the second round of cleaning. The average desire to clean ergonomically was 4.25 out of 5, with 5 corresponding to very well. On average, participants wished to make a 20% postural improvement. All participants saw improvement in their cleaning posture between rounds 1 and 2. The average improvement between rounds was 1.25 fewer mistakes and there was no significant difference between the experimental and control groups.

In addition to data, there were some interesting observations; multiple participants desired more instruction between cleanings on how they could improve. Since participants were not provided these instructions, they did not know how to clean more ergonomically and

expressed confusion. Another observation was made regarding cleaning improvements and speed variation between the two rounds of cleaning. During the second round, all participants cleaned slower and made fewer mistakes. Participants in the experimental group appeared to be more aware of the LED light. This was interpreted as a consequence of participants making efforts towards correcting their wrist posture.

4 Discussion and Future Work

4.1 Discussion

The results of the study demonstrated that workers tended to well respond to real-time wrist feedback when cleaning a window. All participants (both experimental and control groups) saw improvement in their cleaning technique between the first and second rounds, while the experimental group with real-time feedback showed higher perceived system usefulness. In addition, as observed from our expert interviews, ergonomic instruction is critical in affecting behaviour change. Our user study further demonstrated the importance and impact of feedback and usage instruction. Based on participant feedback and observation, simple binary feedback was insufficient in fully informing users on how to make ergonomic improvements to their cleaning technique.

As explained before, the device used during the user study was not fully working; we used Wizard of Oz technique to emulate the design's proposed behaviour. This technique, however, proved valuable because it helped us clarify the contradiction between the initial user interview and the typical suggestion from the literature of design for behaviour change literature.

For future work, we plan to conduct a field study including actual hotel workers cleaning the mirrors or windows of a hotel room. For this, we are currently developing a fully functional interactive prototype that can serve the study as a stimulus (see Section 4.2). Different feedback methods could also be investigated, including instantaneous feedback vs. post session feedback, moving average feedback (how the cleaner is doing in comparison to their own average, their peers' average, etc.), higher or lower threshold level feedback, haptic feedback, only positive or neutral feedback, and only negative or neutral feedback. Furthermore, research should be conducted on the mental effects of receiving this type of feedback (e.g., mood, work satisfaction, stress, social effects). High job demand and low job control—two major characteristics of hotel house cleaning—can lead to psychological problems such as fatigue, anxiety, depression, exhaustion, sleep disruption, and physical illness (Karasek & Theorell, 1990; Sanne, Mykletun, Dahl, Moen, & Tell, 2005).

4.2 Improvement of Erglove prototype

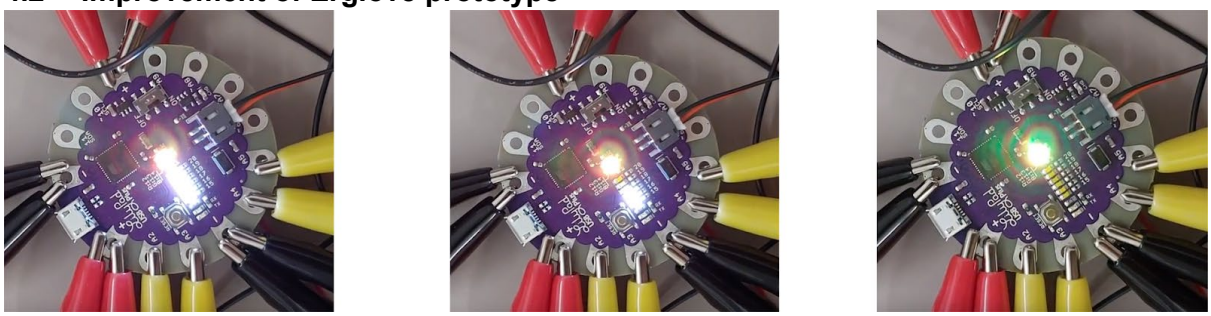

Figure 3. Photo of the real-time feedback bar-graph-like LED from fully flexed (left) to fully relaxed (right), and the long-term feedback colourful LED from red (left) to green (right).

Building on the insights gained from the user study, the concept of Erglove has been further improved and developed into a fully functional prototype. We selected Lilypad USB Plus for the prototype because it is sewable as well as waterproof. Visual feedback, via wrist mounted LED lights, was chosen for this system since most cleaners work alone in their own assigned room with no other people around. The system consists of four flex sensors which are attached to the inner side of an arthritis compression glove to measure four primary types of deflection (ulnar deviation, radial deviation, flexion, and extension), onboard LEDs as visual feedback, and alligator clips to connect all these parts.

Feedback is given according to real-time wrist deflection and the overall wrist risk potential. Real-time feedback is shown in the form of a bar-graph-like LED sequence indicating current flex (deflection) level (Figure 3). These real-time white bar graph lights would allow users to test different postures and figure out a better way to accomplish cleaning tasks. Long-term wrist risk potential is expressed through a coloured LED light, which turns from green to yellow and then red throughout the day if they repetitively clean using poor wrist posture (Figure 4).

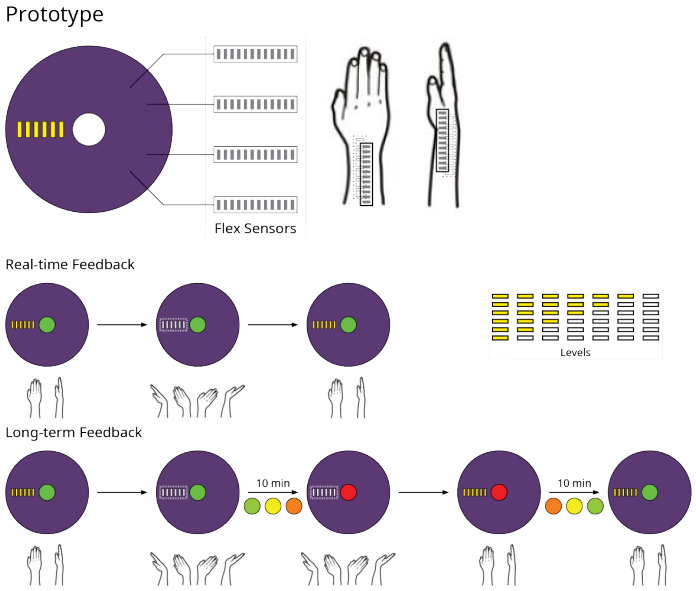

Figure 4. Illustration of Real-time and Long-term Feedbacks. Some resources used in the figure were adapted from (Loh & Muraki, 2014).

5 Conclusion

This paper revealed a new method for alerting hotel housecleaners to an ergonomic issue regarding their wrist postures, and developed a framework and a prototype for them to improve their form and technique, using immediate and long-term feedback. Results from our user study have demonstrated that the system design is functional. Erglove provides inspirations for products designed to change or influence behaviour, stressing the importance of real-time feedback.

The implications of this study likely extend beyond the specific application to wrist MSDs prevention for hotel housecleaners. Our user study was a behaviour intervention to a simple physical task. The results of our study may be applicable to a wide variety of everyday tasks.

Carefully implemented real time feedback could become a powerful tool in improving health across a variety of modalities. Our exploratory study tested one form of real time feedback and further iteration will lead to more effective and beneficial forms of feedback.

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Exploring User Recognition of Motion Pictograms Designed for Providing Disaster-Related Information

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A clear global trend exists toward compound disasters. In Taiwan, short message service (SMS) text messages are currently used to convey disaster-related information. However, due to word limits inherent to the technology, the content only consists of the time, place, and intensity as well as a safety reminder, meaning that information regarding prevention and shelter to mitigate compound disasters cannot be provided. To resolve this, the present study designed motion pictograms for presenting disaster information that can include diverse information about disasters and facilitate rapid communication and understanding across different languages and cultures. The experiment was based on four major disasters that can occur in Taiwan, namely earthquakes, tsunamis, typhoons, and torrential rains, as well as two follow-on disasters (i.e., flood and debris flow). This study invited design experts to design motion pictograms on the basis of a focus group method and conducted a recognition survey. The results showed that recognition of the six disaster emergency motion pictograms designed in this study was higher than the ISO standard of 66.7%. In addition, the optimal playback length of the motion pictograms should be between 0.2 and 0.5 seconds to avoid user fatigue or boredom.

Keywords: motion pictogram; disaster emergency; visual presentation; recognition

1 Introduction

1.1 Research background and aim

The Taiwan Science Report on Climate Change (2011) noted that, due to factors such as extreme climate conditions and land use changes, disaster patterns are gradually trending toward compound disasters. Apart from television, radio, and the Internet, the quickest disaster warning and prevention method in Taiwan is short message service (SMS) text message reminders. However, due to word limits inherent to the technology, information in the message can only provide the disaster time, location, and intensity as well as safety reminders. A lack of information regarding disaster response methods, prevention techniques, and evacuation locations can cause the public to not know how to respond in the event of a disaster.

Pictograms are often used as auxiliary tools for message transmission because they can quickly identify and convey information across languages and cultures while both informing and guiding the viewer. Due to the diverse media landscape of the modern world, people are

spending less time reading and often prefer visual forms of communication. Problems caused by the use of a single pictogram such as those related to message presentation, miscommunication, and possible misunderstanding can be offset by the use of a motion pictogram. Motion pictograms can be used to present a more complete narrative context as well as the categories, attributes, and other information regarding an event. According to Solso(1994), people find motion pictograms attractive and functional. Therefore, by using motion pictograms that integrate disaster emergency messages with corresponding solutions, the effectiveness of disaster prevention awareness efforts and education can be improved.

To date, no countries employ motion pictograms to convey disaster emergency messages. Given the limits of SMS disaster emergency message content, and to provide the public with a more informative system, this study designed a series of disaster emergency motion pictograms and confirmed the effectiveness of their visual presentation and message transmission by testing people's recognition of the messages conveyed.

1.2 Research limitations

The motion pictograms in this study focused on common natural disasters in Taiwan. Graphics and motion transition were the main focuses of the designs in this study; colour and use of sound effects would be studied at the next stage. In the experimental part of the study, a digital native group (participants) as defined by Prensky (2001) was selected to confirm the recognition accuracy. The participants were aged between 20 and 30 years, familiar with digital technology, and were comfortable with controlling multimedia experiences. A questionnaire was employed as the experimental instrument, with recognition recorded by the participants using mobile phone displays.

2 Literature review

2.1 Motion pictogram design

Otto Neurath introduced the International System of Typographic Picture Education (Isotype), a "language-like" graphic design that has become a universal language in the field of education and public pictogram design (Chao & Hu, 2014). A pictogram is a meaningful shape that can replace linguistic transmission to ensure that a message is understood quickly. Hsu et al. (2015) asserted that graphic designs require two cognitive levels. The first level comprises visibility, readability, and simplicity, and the second level comprises construction (i.e., the overall effect of the image), semantics (i.e., the meaning of the image), and usage (i.e., the practicality of the image).。Ōta (2003) argued that an efficient pictogram must undergo detail removal to present a simple and concise image that is highly recognizable and aesthetic so that its meaning can be understood in a short time.

The pictogram designs in this study were based on the study of Ho and Cheng (2013) on human attention and images. If a screen is viewed as a two-by-two grid, then most people's focus lies in the upper-left corner. However, if quadrant analysis is performed, messages in the second quadrant are the most effective, meaning that the most essential messages should be placed in the second quadrant of the screen. Moreover, Ōno et al. (2011) noted that graphics should employ clear actions, motions, and props to improve viewers' understanding of the intended meaning.

Due to technological advancements and the diversified modern media landscape, the belief that multisensory experiences are preferable has led to an increased pursuit of using visual

communication methods, which is demonstrated by the emergence of motion pictograms. According to Fang and Teng (2015), the emergence of motion pictograms satisfies the long-term preference of humanity for viewing moving images. In addition to maintaining advantages of static pictograms, motion pictograms can compensate for the weaknesses of static pictograms. Elements of motion graphics can be divided into object movement, color, form, sound, voice over, and camera movement (Tim et al., 2012). Graphics show the object's color and form while only indicating the movement, an, whereas motion pictograms can directly show the object's movement to convey messages dynamically and visually, which facilitates faster message recognition among viewers. However, designing motion pictograms is more challenging than nondynamic graphics in terms of complexity; each image, scene, and transition must involve the recognition, understanding, and aesthetics of graphic transmission. Motion pictograms can, through their meanings and guidance, symbolize and replace tangible objects and locations as well as intangible behaviors and values (Lin, 1996). Chen and Kuan (2012) also noted that motion pictograms must employ easily identifiable graphics that meet the aesthetic expectations of their era.

2.2 Image recognition and cognition

Nielsen et al. (1990) proposed 10 heuristic criteria for conducting evaluations of pictogram: (1) use simple conversations, (2) use language familiar to users, (3) reduce the need for users to memorize information, (4) employ a consistent interface, (5) have a user feedback mechanism, (6) utilize simple solutions, (7) design shortcut keys, (8) provide clear error messages, (9) prevent errors from occurring, and (10) explain the operational processes. These criteria were followed during the expert focus group to provide references for the designers of the motion pictograms.

In a vocabulary survey of motion pictograms, Chen (2014) proposed five groups of adjectives under the following headings: recognizability, likeability, comfortability, aesthetic quality, and noteworthiness. In this study, the ISO/TR 7239 standard regarding development and principles for application of public information symbols was used as the basis for recognition evaluation of the designed motion pictograms. The evaluation results referred to the ISO 9186-1 benchmark of 67% as indicating accurate recognition of basic motion pictograms (Easterby & Zwaga, 1984). Using the aforementioned evaluation criteria, this study designed an evaluation of the motion pictograms that examined basic recognition of graphic visibility, readability, and simplicity to provide a highly practical method of examining the pictograms' construction, semantics, and usage.

3 Methodology

3.1 Research framework and evaluation method

The framework of this study is outlined in Figure 1. First, confirmation and analysis of disaster definitions, situations, intensity levels, response methods, and warnings was conducted through interviews with disaster prevention experts familiar with common disasters in Taiwan. After data collection, six major disasters in Taiwan were summarized, and the narrative context of those disasters as well as the contingency and evacuation methods were utilized to create scripts that could help in creating visual depictions. Second, an expert focus group was held to help create the basic pictograms. Ten professional designers, each with more than a year of visual design experience, were invited to participate in the interviews and divided into two groups of three and one group of four. Each

person was then asked to create a disaster emergency pictogram and an accompanying dynamic transition.

Subsequently, design elements that were suitable as representative graphics were consolidated from the three groups' disaster emergency pictogram designs and dynamic modes. The design elements were further refined in black and white drafts to produce smooth motion graphics; these were used as the samples for the recognition questionnaire. Motion pictograms with poor designs and low recognition were improved and corrected based on feedback from the questionnaire. Finally, adjustment and unification of the overall style were performed to produce a series of verified disaster emergency motion pictograms.

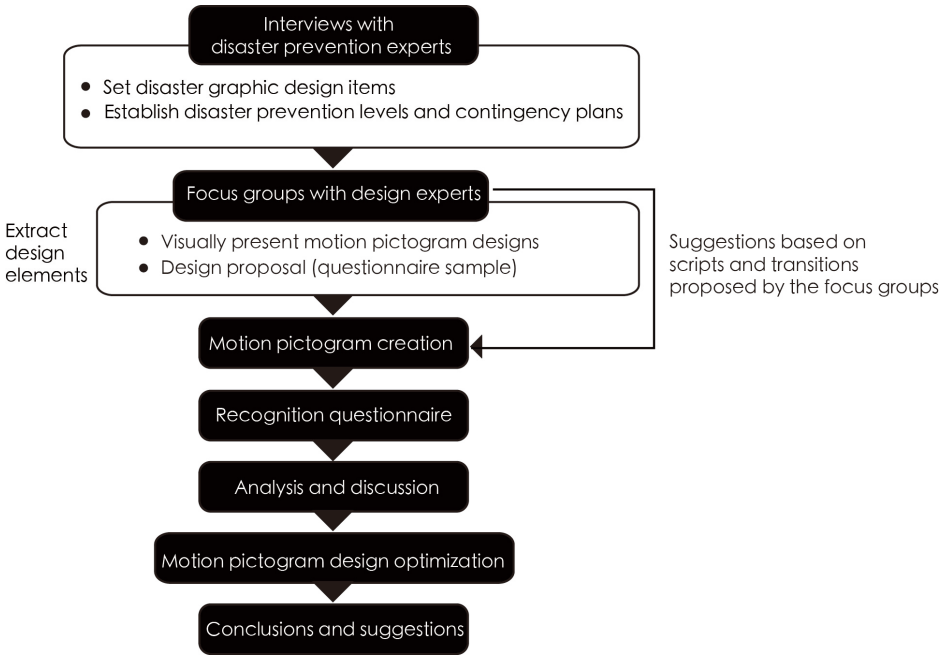

Figure 1. Research framework

3.2 Data processing and analysis

3.2.1 Research tool and data processing

The research tools used in this study were structured interviews, expert focus groups, and questionnaires. The advantage of structured interviews is that they could directly and effectively obtain appropriate strategies adopted by the Taiwan authorities for various disasters, including responses and evacuation methods, with a focus on the research questions.

During the expert focus groups, the research background and aim were first explained, and the disaster prevention interview materials and related pictogram examples were provided to the designers to provide them with inspiration. Each group was given an A4 sheet of white paper with a 5-cm^2 grid space in which to draw their pictogram (Figure 2). In addition, plain paper and stationery were provided to enable the designers to draft ideas and create a motion storyboard. During the group discussions, electronic products were permitted to help the groups search for information. Moreover, to avoid influence from extraneous factors, all images were depicted in black and white.

For the recognition questionnaire, the participants were asked to watch the disaster emergency motion pictograms on a mobile device and subsequently answer a questionnaire.

The content of the questionnaire was divided into three parts. The first part was the participant's basic information. The second part employed a 5-point Likert scale to evaluate six disaster emergency motion pictograms. The evaluation referred to the items proposed by Chen (2014), and adjust the adjectives namely recognizability, comfortability, noteworthiness, and design quality. The third part was an open-ended question (i.e., suggest changes according to disaster types, response methods, and graphical correlation).

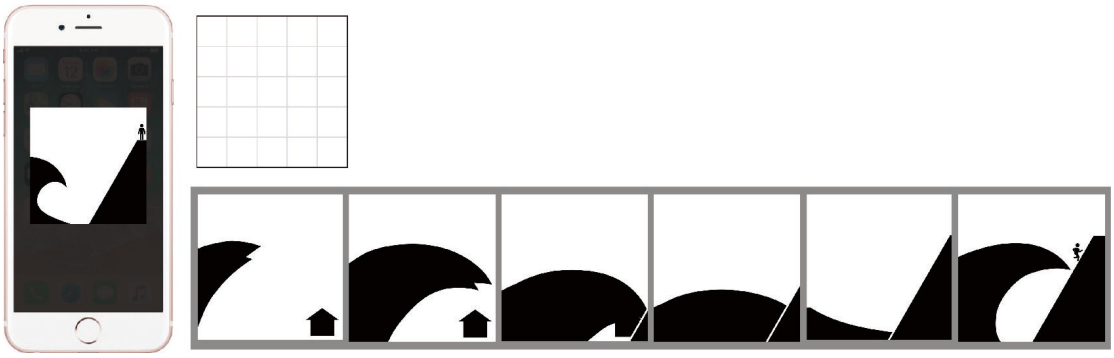

Figure 2. Presentation of the motion pictogram on a mobile device

3.2.2 Depiction and statistical analysis

Adobe Illustrator CC was employed to refine the black and white artwork, and Adobe After Effects CS6 was used for motion pictogram production. The motion pictogram was produced at 500 × 500 pixels.

Considering the need for urgency with emergency disaster graphic transmission and to avoid overly elaborate transitions, fade in–fade out and left to right transitions was set according to the different types of disasters. The pictogram had lengths of 2–5 seconds and was played on a loop. The file output format was MP4 (29.97 FPS).

SPSS 22.0 was used to analyze the quantitative data from the questionnaires. In addition to descriptive statistics, correlation coefficient analysis was employed to understand what factors correlated with recognition of the evaluated motion pictograms.

4 Results and discussion

4.1 Disaster emergency motion pictogram design items and visual presentation

After interviews with experts, six disaster types were recognized as well as 13 design items, as shown in Table 1. The graphics for each disaster needed to indicate whether follow-on disasters might occur, because flood and debris flow are follow-on disasters of typhoon and torrential rain that do not occur independently.

Table 1 Design items for the disaster emergency motion pictogram

Disaster Item	Earthquake	Tsunami	Torrential rain	Typhoon	Typhoon and flood (vertical evacuation)	Torrential rain and debris flow
Response/ emergency evacuation method	(1) Protect your head and hide under the table (2) Escape the building and gather in an open space	Escape to higher ground	Stay indoors	Stay indoors	(1) Yellow alert: store water (2) Red alert: vertical evacuation	Evacuate to shelter

Expert groups formed by 10 professional visual designers created the disaster emergency motion pictograms. The created motion graphics were used as samples for the recognition questionnaire (Figure 3).

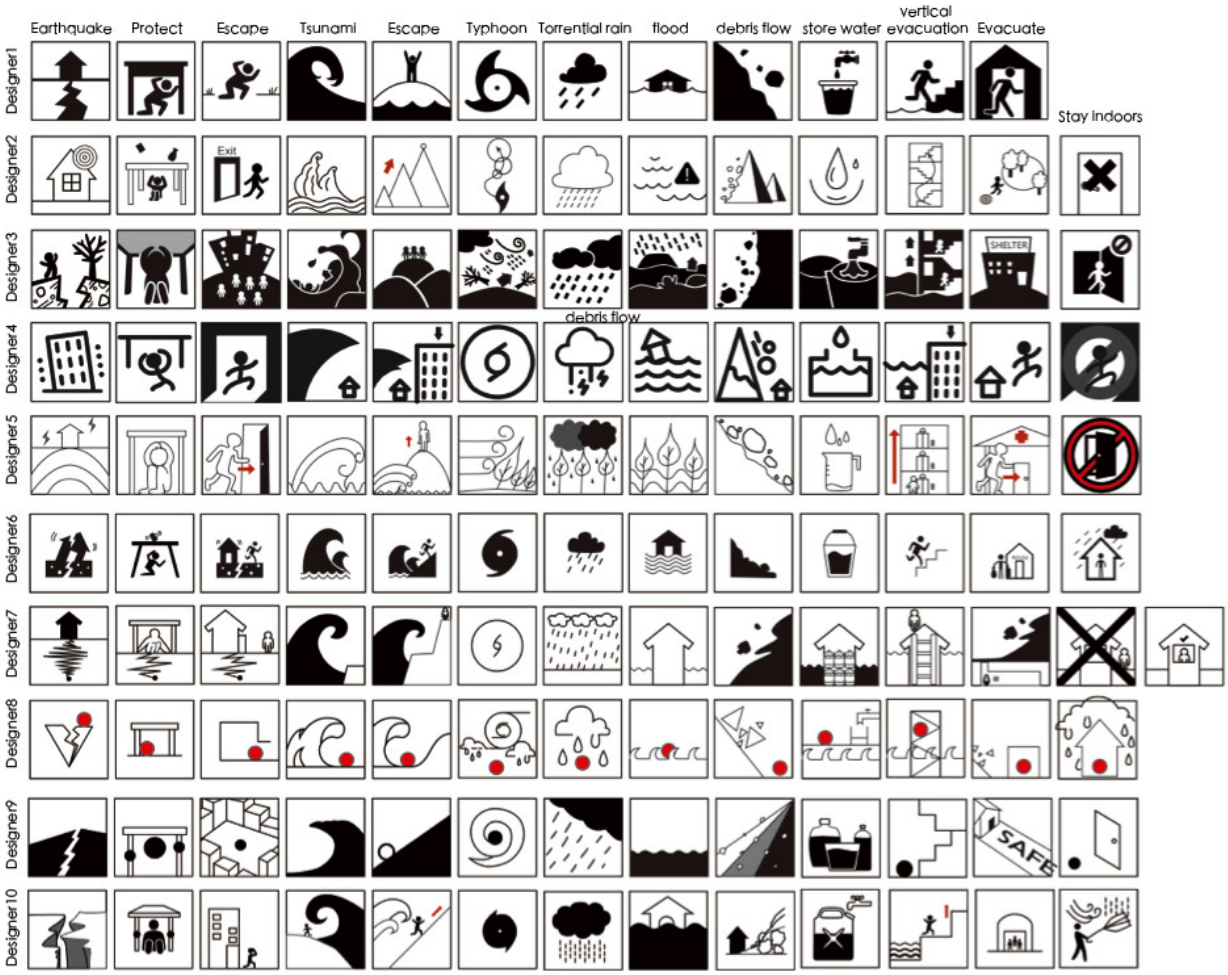

Figure 3. Storyboard for visual representation of the disaster emergency pictograms

The groups' analyses of the design items and sample pictograms came to the following conclusions: (1) pictographic representation should be adopted, with combination images used as alternatives. Combined graphics should be used only when pictograms cannot accurately illustrate the concept, such as for shock waves and typhoons. (2) Colors and lines should be used together, because designers rarely only use one. (3) Houses should be drawn with a pointed roof because house shapes are mostly designed with pointed roofs, 45° eaves, and a square main body. (4) Graphics should use two-dimensional designs. Although graphics can be presented in three-dimensional forms, all graphics should be unified into two-dimensions considering style uniformity and ease of understanding. (5) The motion graphics should move from left to right because people often evacuate from the left to the right.

4.2 Recognition questionnaire results

4.2.1 Depiction and statistical analysis

A total of 40 valid questionnaire responses were obtained, with an even distribution of male and female respondents. The respondents were degree holders aged between 20 and 30 years, with 67.5% having a design background. Up to 85% of the participants had previously

received SMS disaster emergency messages, with the most common category of disaster emergency for which they had received a notification being an earthquake. The evaluation results of the criteria (i.e., recognizability, comfortability, noteworthiness, and design quality) are presented in Table 2.

Table 2 Statistical results of recognition

Item (Correct answer)		Earthquake		Tsunami		Torrential rain (Stay indoors)		Typhoon and flood (Store water)		Typhoon and flood (Vertical evacuation)		Torrential rain and debris flow		
Recognizability	Understand type of disasters	97.5%		97.5%		72.5%		97.5%		95%		90%		
	Understanding disaster response methods	• Hide under the table (85%) • Run away (60%) • Leave the building (32.5%) • Gather at open space (5%) • Avoid falling objects (2.5%) • Escape the building when the earthquake stops (17.5%)		• Run to a higher place (85%) • Run away (2.5%) • Escape from the shore (2.5%)		• Stay indoors (97.5%)		• Store water (92.5%) • Stay indoors (7.5%)		• Run to a higher floor (97.5%)		• Run away (35%) • Escape to shelter (32.5%) • Escape to a safe zone (20%)		
		MD	SD	MD	SD	MD	SD	MD	SD	MD	SD	MD	SD	Overall average
Comfortability	Speed of motion is too fast	3.25	.82	3.50	.77	3.90	.76	3.40	.91	3.55	.86	3.65	.90	3.54
	Motion pictogram contains too much information	3.70	1.00	3.80	.81	3.95	.83	3.82	.99	3.42	.91	3.67	.87	3.72
	The motion pictogram is aesthetic	3.06	.81	3.22	.85	3.32	.78	3.37	.85	3.25	.85	3.27	.89	3.24
Noteworthiness	The images drew my attention	3.64	1.10	3.85	1.10	3.82	.89	3.82	.99	3.70	.97	3.82	.94	3.77
	This images were interesting	3.67	1.07	3.85	1.03	3.75	.99	3.77	1.03	3.60	1.06	3.80	1.00	3.74
	The pictogram would be helpful when a disaster occurred	3.35	1.09	3.65	1.10	3.65	.98	3.52	1.13	3.45	1.09	3.65	1.01	3.54
Design quality	Playback of the motion pictogram was smooth	3.83	.93	4.00	.86	3.85	.79	3.80	.84	3.82	.83	3.90	.76	3.86
	I like the style of the motion pictogram.	3.19	.90	3.15	.79	3.22	98	3.15	.96	3.02	.87	3.30	.87	3.17

MD: Mean Deviation, SD: Standard Deviation

The overall recognition scores reveal that recognition of the six motion pictograms achieved recognition of over 67%. Specifically, torrential rain (stay indoors) had the lowest recognition at only 72.5%. The pictogram for this disaster had a lightning sign inserted to distinguish between heavy and torrential rain. However, according to the open-ended survey, most of the participants misunderstood the lightning sign in the graphics to mean thunderstorm. A possible cause of the misunderstanding is that the lightning sign accounted for half of the upper image, which may have attracted participants' attention. This result is also supported in the literature, with one study finding that crucial items occupying half of the upper area during motion graphics playback are particularly likely to draw the attention of users (Ho & Cheng, 2013).

Regarding the arrangement of motion pictogram scripting and presentation time, confused interpretation can occur if images are arranged in the order of major disasters, follow-on disasters, and response methods. In addition, the length of the disaster motion pictogram should be between 0.2 and 0.5 seconds to achieve the greatest communicative and warning effects. Therefore, pictograms for the representative major disasters in this study should include representations for both the primary and follow-on disasters to enhance the efficiency of visual communication.

With regard to design quality, the overall average score for all disasters was 3.24, and the average score for liking the motion pictogram was 3.17. The average score for the design quality of the typhoon and flood (store water) pictogram was the highest with 3.37, whereas for the earthquake pictogram it was the lowest with only 3.06. The torrential rain (debris flow) pictogram had the highest score for liking the pictogram at 3.30, and the typhoon and flood (store water) and tsunami pictograms had the lowest, each being 3.15.

4.2.2 Correlation coefficient analysis

Correlation analysis of the questionnaire items is shown in Table 3. Among the six disaster emergency motion pictograms, the noteworthiness of the image is highly and positively correlated with user's interest. Therefore, designs that focus on immediately drawing users' attention are crucial. Furthermore, the design qualities of the motion pictograms are highly and positively correlated with having a likeable style. Thus, deciding on a consistent and fixed style before designing can effectively improve the user's aesthetic experience.

Table 3 Correlation coefficient analysis of user recognition

Item	Earthquake	Tsunami	Torrential rain (Stay indoors)	Typhoon and flood (Store water)	Typhoon and flood (Vertical evacuation)	Torrential rain (debris flow)	Item
Noteworthiness	0.88 .000**	0.94 .000**	0.85 .000**	0.95 .000**	0.89 .000**	0.91 .000**	Interest-ing to watch
Design quality	0.73 .000**	Nonsigni-ficant	0.84 .000**	0.78 .000**	0.72 .000**	0.76 .000**	Likable style

*** p < 0.001 represents high significance*

4.3 Design optimization and proposal

Based on the questionnaire results, this study determined the optimized design for disaster emergency motion pictograms, which requires presenting compound disasters by combining information regarding primary and follow-on disasters and deleting image elements that may

cause misunderstanding in order to maximize visual communication efficiency. In addition, the length of the motion graphics should be between 0.2 and 0.5 seconds. The improved graphic design is shown in Figure 4.

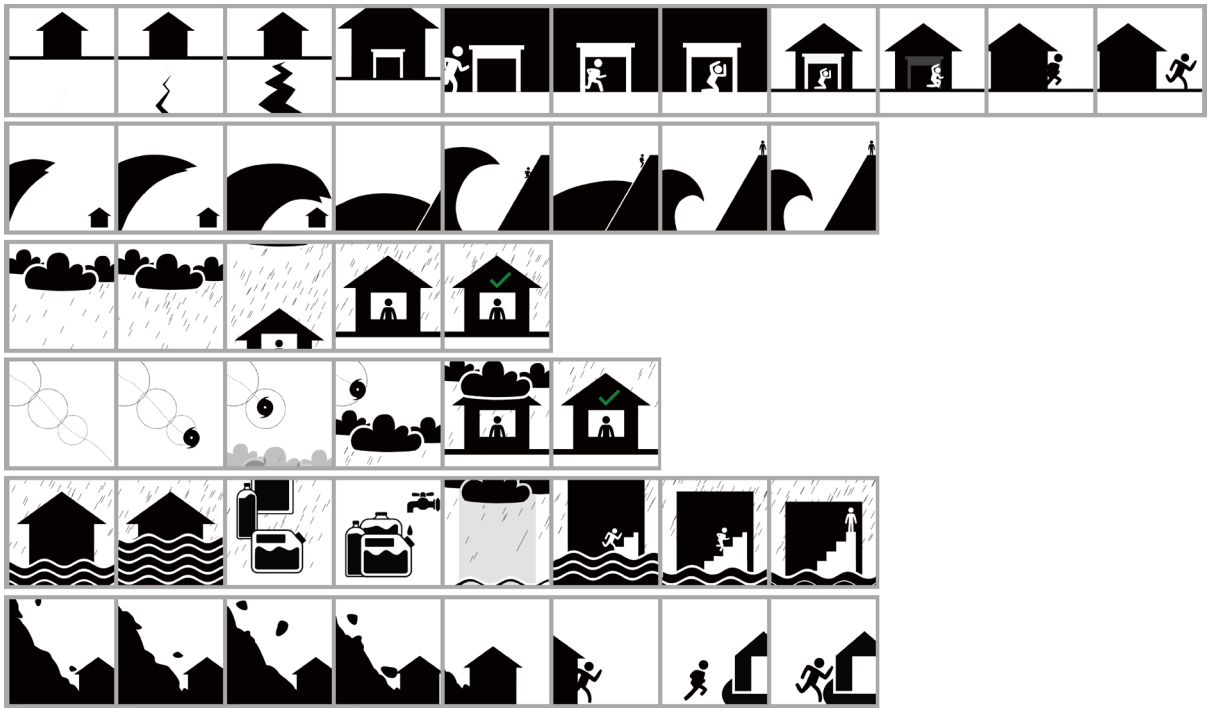

Figure 4. Optimized design proposal for disaster emergency motion pictograms

5 Conclusions and suggestions

Disaster emergency messages are a vital source of disaster and early prevention information. According to the survey, recognition of the motion pictograms designed in this study attained a recognition level greater than the ISO standard of 66.7%, indicating their applicability for practical use. Motion pictograms could replace mobile phone SMS notifications by conveying information within a short time without text, and this study showed that such images could obtain positive responses from people with disaster prevention knowledge. When designing motion pictograms, it should be noted that objects occupying more than half of the screen that appear at the start of the image are highly attractive. If the screen is divided into nine blocks, key moving objects should be placed in the upper middle position to most effectively convey the message. To avoid boredom and misunderstanding, the length of motion graphics should be set between 0.2 and 0.5 seconds.

Designs of pictograms can further be strengthened in the future for international and universal applicability. According to the questionnaire results, many participants suggested adding colour elements to indicate warning levels and urgency. Use of colour in motion graphics and discussion of its symbolic meaning are worth exploring in terms of their effects on visual emotion.

The results of this study can be applied to the development of programs and software for practical use in mobile devices. Moreover, experiments should be conducted on real-world applications to determine any potential problems and help contribute to disaster warning and education.

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Food Balance Lunchbox: Enabling Healthy Eating by Knowledge

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As the rate of obesity arose among South Koreans, the Korean Ministry of Health and Welfare published a visual food-based dietary guideline, *Food Balance Wheel* in 2005. It is supposed to impart personalized nutritional knowledge for healthy eating, i.e., what and how much to eat/drink from five food groups to stay healthy with balanced and nutritious meals. The current Food Balance Wheel design, however, is problematic in that (1) the concepts of moderation and personalized dietary patterns are not represented, (2) the proportionality between five food groups are inaccurately illustrated, and (3) food serving sizes are not visually exemplified. Daily water recommendation is missing. An alternative model, *Food Balance Lunchbox*, is designed in the constant column width (CCW) treemap format for the audience's reduced cognitive burden. A CCW treemap consists of rectangles with equal widths; it is visually simpler than a pie chart, and it allows for fast and easy one-dimensional height comparison of proportionality between five food groups. The concepts of moderation and personalized calorie recommendation are visualized by varying CCW treemap sizes. Food items' serving sizes are exemplified in photographic images to impart more accurate information in volume, weight, and calories. Information on total daily water recommendation that includes water from food and beverages, and the proportionality between three macronutrients (carbohydrates, protein, and fat) information are also provided. With the Food Balance Lunchbox model, we expect consumers to perceive healthy eating actionable daily goals to achieve, not as an abstract concept.

Keywords: food-based dietary guidelines; frequency graph comprehension; proportionality visualization; nutrition knowledge; treemaps

1 Introduction

According to 2018 Korean Ministry of Health and Welfare statistics, the percentage of overweight cases (BMI ≥ 25) have risen from 31.3% in 2005 to 34.8% in 2016, and extreme obese cases (BMI ≥ 30) amount to 5.5% (Lim, 2018). As obesity is linked to an increased risk of lifestyle diseases (diabetes, e.g.), the Korean government published the Dietary Reference Intakes for Koreans (hereafter KDRIs) as a preventive measure. The KDRIs booklet—first published in 2005 and revised twice in 2010 and 2015—is now distributed online, as part of nationwide nutrition education programs at educational/medical institutions, to encourage Koreans to have balanced, nutritious meals in moderation.

The KDRIs booklet (Jung, 2015) consists of chapters on energy and macronutrients, vitamins, minerals, as well as recommended dietary patterns for various life cycle stages and anthropometric characteristics (Figure 1, Jung, 2015, pp.958-959). For an easier understanding and application of the dietary patterns, KDRIs also provides the *Food Balance Wheel*—식품구성자전거 in Korean—as a visual food-based dietary guideline (hereafter FBDG) where items in five food groups are presented in a drawing of a person riding a bicycle (Figure 2, Jung, 2015, p.919).

A Type						
Kcal	Grain	Meat, fish, eggs, beans	vegetables	Fruits	Milk, Dairy products	Oil, sugar
1,000	1	1.5	4	1	2	3
1,100	1.5	1.5	4	1	2	3
~	-	-	-	-	-	-
2,600	3.5	5.5	8	4	2	8
2,700	4	5.5	8	4	2	8
2,800	4	6	8	4	2	8

* Pattern A: 1,000 ~ 2,700 / Pattern B: 1,000 ~ 2,700 (Milk·Dairy products 1 times recommended)

Figure 1. An example of KDRIs dietary patterns table. The pattern A applies to infant and youth population who need two servings of dairy products, while the pattern B is for adults.

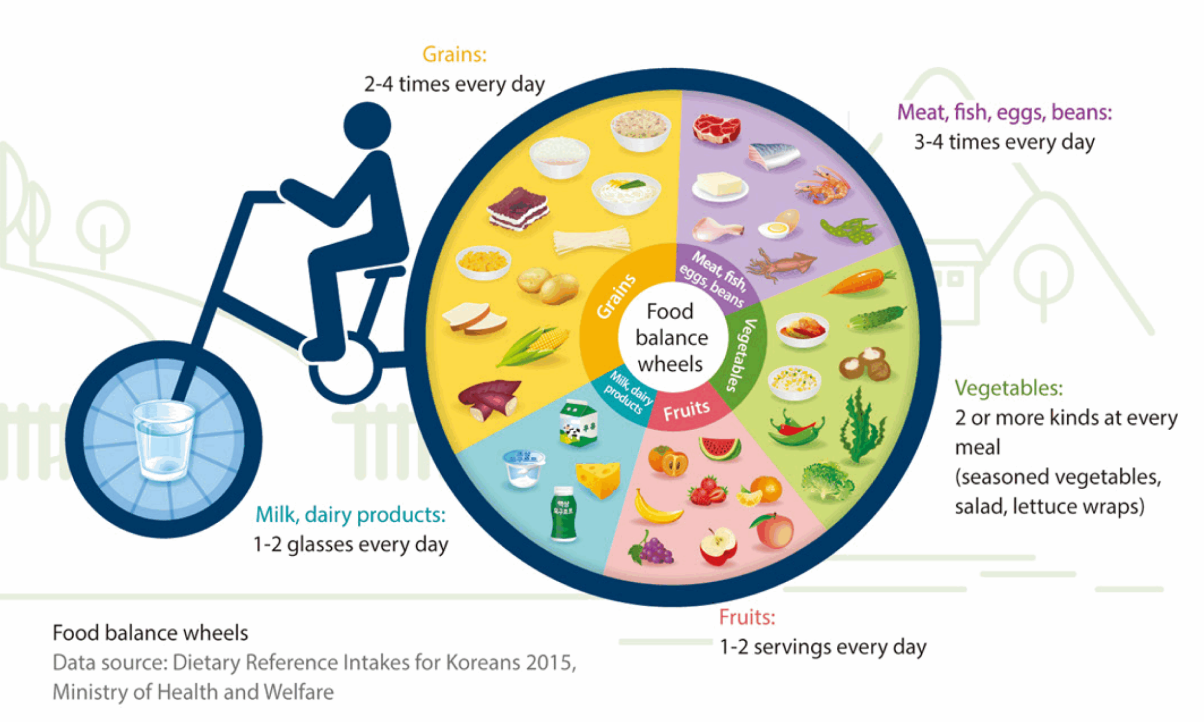

Figure 2. The Food Balance Wheel in the KDRIs booklet.

Ideally, food-based dietary guidelines are supposed to visualize concepts of **moderation, diversity, proportionality, and hydration** (Figure 3) for a healthy and balanced diet. Also, the information should be personalized according to each person's age, height, weight, and physical activity level for moderation. For this reason, the KDRIs booklet list up 37 calorie cases as recommended dietary patterns (Figure 1, Jung, 2015, pp. 958-959): 19 for children and adolescents (Pattern A), and 18 adults (Pattern B). For each case, recommended servings from five food groups differ.

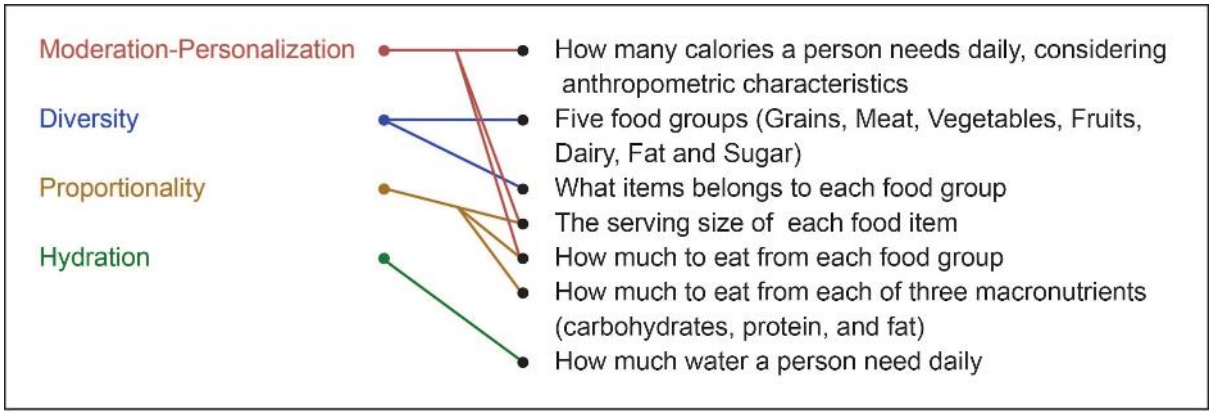

Figure 3. Information requirements for visual food-based dietary guidelines.

The KDRIs booklet, however, is a 55-page long scientific document, and it is neither practical to expect most Korean adults to carefully read and remember what it says, nor Korean children to fully grasp its complicated scientific terms. For the reason, visualized FBDGs—the Food Balance Wheel (Figure 2)—is called for as an executive summary version of the booklet, to inform what both children and adults practically need to know for healthy eating. The bicycle metaphor emphasizes the concept of balance: a balanced diet, and a balance between nutrition and physical activities. The bicycle rider image is easy to grasp and memorable, even for children. The proportionality between five food groups is visualized in a pie chart, a popular frequency comparison chart most Koreans are familiar with.

Our qualitative study with 37 college students, however, revealed many communication problems of the bicycle model.

- The concept of **moderation** and **personalized** dietary patterns are not presented there, because the model is distributed as a sheet of printable image. To encompass all 37 calorie cases, servings in each food group are written in range values ("Eat from the Grains group 2-4 times daily"), which can be rather ambiguous to everyone.
- **Diversity** is exemplified with illustrated food icons, but the icons are presented without labels, so some are not identifiable. Food icons are also presented as the whole (a bunch of grapes, e.g.) to make it recognizable with ease, while a serving of fruit is usually smaller than that (a third of the whole grape bunch, e.g.). As **serving size information** is missing on the model, you do not know how large a serving is, and cannot follow the guidelines in the dining context.

- **Proportionality** information is distorted: Meat group slice look almost as large as Vegetables group slice while the recommended Vegetables intake is always higher in servings and heavier in weight.
- The concept of **hydration** is illustrated with a cup of water on the front wheel, but information on exactly how much water you should drink is missing.

In a word, the Food Balance Wheel has problems of ambiguous and misleading information. Such findings led us to develop alternative models that are improved on the design (format, colour, and icon style) and the content (text information and icon label) for more personalized and accurate food knowledge.

One of the basic assumptions in this study is imparting apprehensible nutrition knowledge will lead to the consumer's improved food behaviour. In fact, many scientific investigations are conducted on the correlation between knowledge and behaviour change, and the results are still inconsistent. For instance, Puttapitakpong et al. (2014) investigated 430 women's knowledge on osteoporosis prevention; they found that 85.2% of the participants had adequate knowledge about osteoporosis, and 53.3% of them had good attitudes towards osteoporosis prevention, but preventive behaviour is only correlated with attitude, not with the knowledge level. The knowledge level, however, is linked to positive attitudes toward osteoporosis prevention that lead to prevention behaviours. On the contrary, other studies find positive linkage between knowledge and healthy behaviours. Ghannadi et al. (2016)'s study with 117 Type 2 diabetes patients finds significant correlation between patients' knowledge and practicing self-care activities. Jang's study with 300 Korean college students (2010) concludes that subjects with higher nutritional knowledge spend longer time for eating; they eat fruits and vegetables more frequently and avoid animal fat and fried food, compared to other subjects; they also prefer fish, egg, beans and other soy-based foods, milk, spinach, cucumber, while low nutrition knowledge group subjects prefer instant and fast foods. Park (2016) also reports that college students with higher nutrition knowledge consider nutrition information on cafeteria menus trustworthy and understandable, so they are more inclined to read nutrition information and choose healthier options in dining context.

Based on previous studies, this study also hypothesizes that providing concrete and straightforward knowledge on nutrition will lead to improved eating behaviours. While *healthy eating* is abstract and ambiguous concept for most consumers, translating it into easy and plain terms ("eat three Grains servings daily, and examples are two slices of bread, a rice bowl, and a noodle bowl", e.g.) will affect the consumer's *perceived behaviour control*, i.e., "people's perception of the ease or difficulty of performing the behaviour of interest" (Ajzen, 1991, p. 183). People tend to carry out a behaviour more frequently when they think it is easy to do. If they regard *healthy eating* as sufficiently fathomable and doable, they are more likely to follow recommended FBDGs.

Another hypothesis is that providing actionable goals to meet will lead to healthier eating behaviours. Specific examples of eating healthy in the KDRIs booklet and the Food Balance Wheel are a clear *reference value* as suggested in Control Theory (Carver & Scheier, 1982). If people are given sufficiently personalized food-based dietary guidelines, they can simply compare their current diets to the reference value and try to adjust, without struggling too much to find out what, how and how much to eat to stay healthy.

In summary, hypothesizing that educating adult consumers with concrete and actionable nutrition knowledge is conducive to healthier eating behaviours, this study (1) discusses inaccurate and insufficient information in the current *Food Balance Wheel* and (2) proposes an alternative dietary guideline model for improved communication. Before designing new models, the research team reviewed various FBDG models from all over the world for inspirations, as summarized in the following section.

2 Food-based Dietary Guidelines

Each country's FBDGs is designed considering the agricultural production system, culinary tradition, and lifestyle-induced health issues specific to the country. Visual styles (format, colour, and icon style, if there is any) of the guidelines differ, and in some countries, scientific studies were conducted during the development process to find out which style options are preferred by consumers or effective in communication; such findings are particularly insightful in the design of an alternative Korean FBDGs.

2.1 Formats: Pyramid, Pie, and Others

Visualization allows for an intuitive and progressive understanding of complex data, as diagrams shed lights on the conceptual structures of information (Oxman & Planning, 1997), and knowledge captured in a dynamic diagram can facilitate a group's decision-making process based on a shared understanding of given information (Eppler & Kernbach, 2016). FBDGs from various countries visualize current ideas of what constitutes a healthy diet in each country, and they elicit discussions through which the ideas evolve and develop.

Montagnese et al. (2015) reviewed FBDGs in 34 European countries and found that 67% of them are designed in the pyramid format. While the format is popular and considered familiar to many, in the U.S., it stirred a controversy of whether the food items in the top section is superior to others in nutrition as they are the highest in the vertical position, or you need to eat them in moderation because they occupy the smallest area (Perelman, 2011). Thanks to the lessons, recently developed pyramid-shaped FBDGs come with design elements to clarify it. For instance, Germans built a 3D Food Pyramid (Oberritter et al., 2013): a doughnut chart of six food groups is presented at the bottom and items in each group are listed on the four triangular sides. Less healthy items are placed higher and occupy smaller space than healthier options. A narrow, red–green spectrum printed on the side indicates which one is recommended to eat more. Japanese cleverly dodged this issue by turning a pyramid upside down to make it inversely conical (like a spinning top), so the smallest space goes to the bottom ("Japanese Food Guide Spinning Top", n.d.).

Other than the pyramid, pie charts (with the metaphor of a plate) are the second popular choice. One of them is the UK model, the Eatwell Guide, most recently revised in March 2016. In its development process, Hunt et al. (1995) tested 10 different designs of the model, made in combinations of three formats (pyramid, flat pie chart, or tiled pie chart), 2 colour schemes (multicolour or single colour), and two food item presentation styles (colour photos or line illustrations). With the participating public and nutrition educators, which design is preferred, more memorable, or communicates better are investigated. The study concludes that consumers prefer *the single-color tilted pie chart with food photos* design the most, and *the multi-colour pyramid with illustration* designs second most, but *the single-color tilted pie chart with food photo* design is also among the three least favoured designs, so the findings

are debatable. The findings—circular format is preferred to pyramid, and photos are preferred to illustrations—are, in fact, congruent with what Talati et al.'s qualitative study (2017) with Australian consumers concluded. Hunt et al. (1995) found, however, that the design of FBDGs is not significantly correlated to their communicating performance of food groups and proportionality, as much as the study subjects' gender, age, or their socio-economic groups do.

More format variants exist. The Hungarian model is drawn after a house of 5 sections. Larger rectangular areas are assigned to vegetable and grain groups, the smallest area of the chimney shows moderate intake of sugar and fat. The triangular roof is not entirely symmetrical – Meat area on the left is larger than Milk area on the right (Montagnese et al, 2015, p.210). The French model is a column chart metaphorically described as stairs. Each column is intuitively drawn in proportion to the amount of food intake from each group. People climbing up the stairs conveys two-fold messages: (1) importance of exercise and (2) reaching the goal of living healthy by eating more vegetables and keep hydrated on the last, highest column.

2.2 Korean Food Balance Wheel Model

In comparison to the American and European models, the Korean Food Balance Wheel model (Figure 2) is unique in format: a stick-figure person riding a bicycle. Functionally the model consists of two pie charts, the front wheel for water, and the rear wheel assigned to five food groups. It emphasizes regular physical activity as a critical part of a healthy lifestyle. While the key messages of balanced diet (diversity) and exercise were sufficiently communicated, the Food Balance Wheel performed poor in communicating how to eat healthy in Hong (2013)'s study with elementary school students, and the authors' own unpublished qualitative study with 35 adults. The model failed to accurately clarify the following information.

(a) personalization-moderation: the personalized recommendation of daily calorie intake. Being a static image, the Food Balance Wheel fails to individuate 37 cases (from 1000 to 2700 kcal) of personalized dietary patterns, i.e., recommended servings in 5 food groups. On the model, servings in each food group are written in range values (Figure 2, "2-4 times a day from the Grains group", e.g.), so it is open for arbitrary interpretation. As a result, the majority of Hong (2013)'s study participants answered they should eat three Grains servings per day as they habitually eat three meals daily, but female students' recommended Grains servings are 2 or 2.5.

(b) proportionality: the recommended ratio of food intake from each food group. In the Food Balance Wheel, slices are ordered from wide to narrow (Grains, Meat, Vegetables, Fruits, and Dairy) with exceptions of Meat and Vegetables. Such design of pie chart is misleading in two aspects:

- It is not clear what slice widths are proportionate to—the number of servings, weight of food, volume of food, or calories—though the slices appear to indicate how much to eat from each group.
- Current arranging order and slice size (Figure 4, Meat comes before Vegetables, and the Vegetable slice is only slightly larger than the Meat) can be misleading. In Hong (2013)'s study, some male students think they should eat more meat than vegetables, while both the recommended servings and weight are higher in the

Vegetables group (Figure 1). In authors' own unpublished study, most subjects also failed to read that they should eat more vegetables than meat from the Food Balance Wheel. Two possible causes are (1) the misleading design of Food Balance Wheel, and (2) the subjects' groundless belief that protein should take up about 30% of the daily calorie intake, while experts' recommendation is between 7-20% (Jung, 2015, p. 927).

In summary, the rear wheel in the bicycle model fails to communicate personalized dietary patterns, and its slice widths are misleading the audience.

(c) hydration: recommended daily water intake. On the Food Balance Wheel, how much water you should drink and if it includes water from food is not clarified. Hong (2013)'s study participants said drinking 500-1000ml of water was enough per day, while recommendations are 1900ml for girls and 2100ml for boys, including water from food (Jung, 2015, p.213). Here are interesting insights we gathered on how the two wheels are interpreted in the authors' own qualitative study:

Front wheel slices (12) are the cups of water you need to drink.

Rear wheel slices (6) are the cups of water you need to drink, one per each food group.

The ratio between front and rear wheel diameters is the water to food ratio.

The ratio between front and rear wheel areas is about 1:10, so....

Subjects who could not find any hints from the bicycle model simply answered "I cannot tell from the Food Balance Wheel, but I hear I need 2000 ml of water", as they heard from various news media. On hydration, the Food Balance Wheel is not informative but just confusing.

3 Food Balance Lunchbox: Alternative Models Development

In response to the weak performance of current Food Balance Wheel as a pie chart, the authors chose to develop an alternative model in constant-column width (hereafter CCW) treemap format. The new model is titled *Food Balance Lunchbox*, because of its two-dimensional structure of a square divided into five sections looks similar to the top view of typical lunchboxes sold in Korean convenient stores. Following design variables are considered.

(1) Proportionality visualization: Though widely used for visualizing frequency data, Cleveland and McGill (1984, as cited in Huestegge & Pötzsch, 2018) pointed out that a pie chart is complex as a shape thanks to its curved and straight lines, and the different orientations of pie slices (if the slices are not adjacent) add more cognitive difficulties of mentally rotating them prior to comparison (Figure 4). In contrast, previous studies report superiority of the bar chart and CCW treemap to the pie chart in quantity comparison (Huestegge & Pötzsch, 2018, p. 213). Column charts and CCW treemaps (Figure 5)—de facto column charts, you need to compare slice heights only—are:

- Simpler in shape
- They allow for one-dimensional comparison of length

- Higher space efficiency: labels can be placed within the chart.
- CCW treemaps also provide “additional visual anchors for proportion judgments” such as a quarter, a half as is in a pie chart

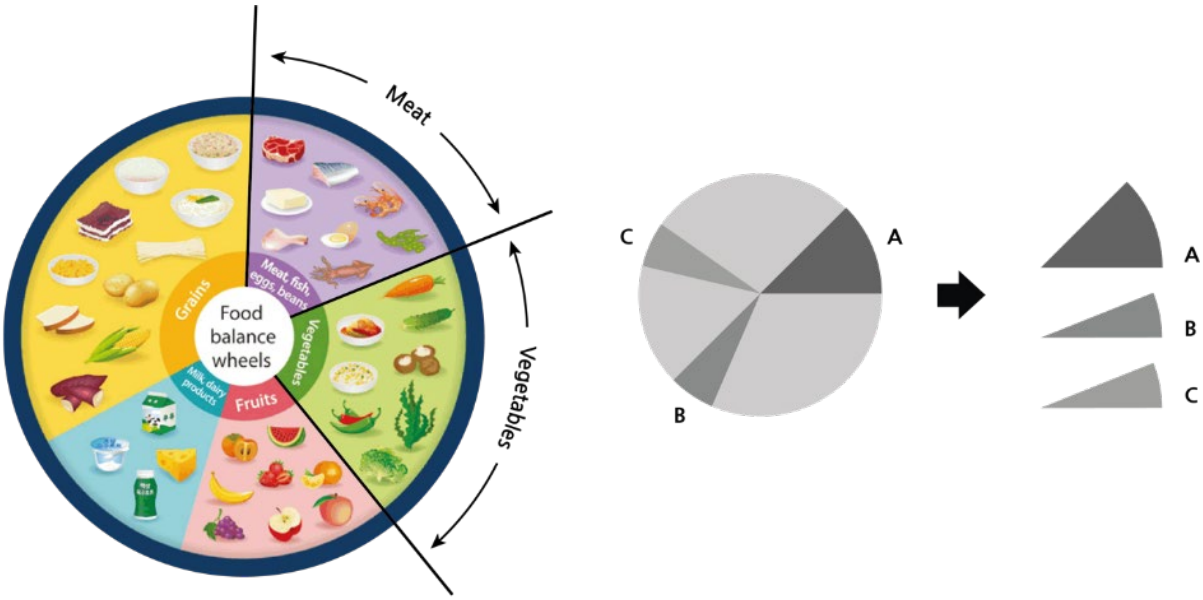

Figure 4. The current Food Balance Wheel and its cognitive issues. Current arranging order and slice size of five food groups are misleading (left). In the pie chart, slices require mentally rotating them prior to comparison (right).

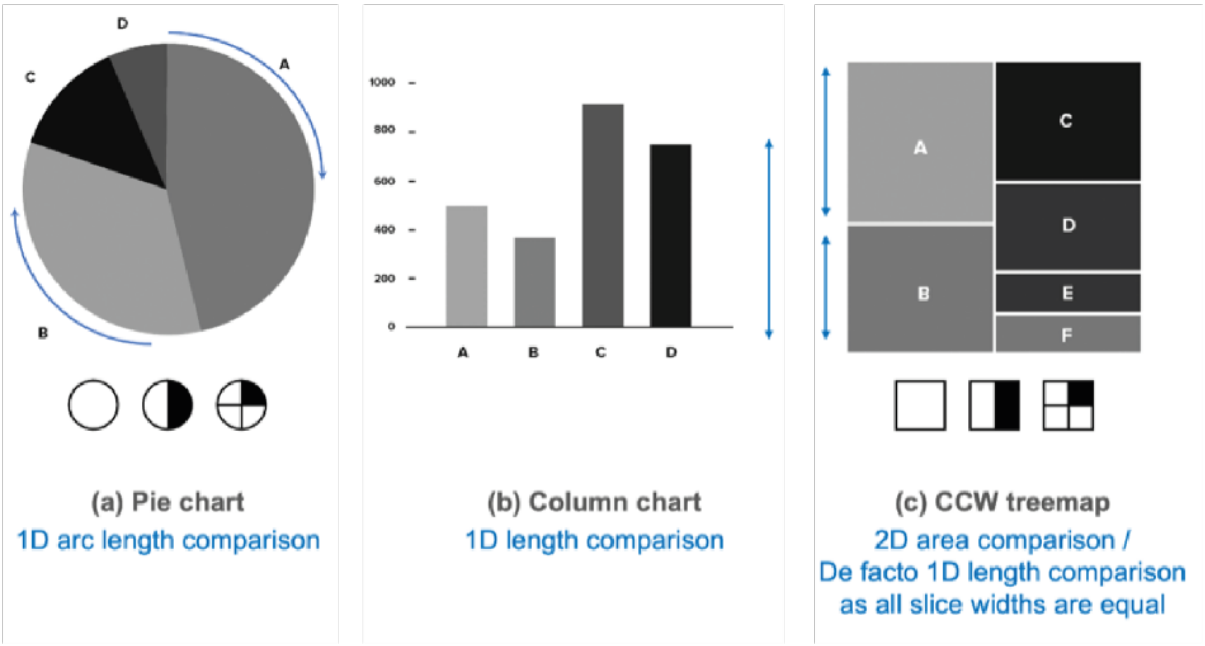

Figure 5. A comparison of pie chart, column chart, and CCW treemap formats. Pie chart and CCW treemap formats provide additional visual hints such as a half or a quarter. In the column chart and CCW treemap, labels look more organized.

Such findings inspired us to design the first alternative model in CCW treemap formats (Figure 6). For the print version, treemap areas are drawn in proportion to weight(gram) of a representative item in each food group—for example, a rice bowl (210g) in the Grains group—for the following reasons.

- Recommended dietary patterns are written in servings. A serving in five food groups are different in calories, which is unknown to most people: A Grains serving is 300kcal, a Meat serving is 100kcal, while a Vegetables serving is 15kcal. A serving in five food groups are also different in weight, depend on specific food items. Visualizing proportionality based solely on the number of servings can inaccurately illustrate the proportionality between food groups.
- Proportionality between food groups is best calculated in calories, but for consumers, estimating-calculating food calories in the dining context is difficult.
- When people eat, weight and volume are tangible and easy cues to guess serving sizes.

In the Food Balance Lunchbox, food group slice sizes are calculated in weight of the representative food of the group. Recommended daily servings are also written in each food group slice.

(2) Scalability for moderation-personalization visualization: The Food Balance Lunchbox in CCW treemap formats are also easier to be scaled up or down, for visualizing quantitative differences of 37 calorie cases. For example, three calorie cases of B1200kcal, B1700kcal, and B2500 kcal CCW treemaps will be drawn in different sizes (Figure 7, left).

(3) Photographic food icons for diversity and serving size representation: In place of current food illustrations, Food Balance Lunchbox shows colour photos of food items that accurately portray diverse food items to the last step of classification (rice, brown rice, or multigrain steamed rice, e.g.), instead of just saying “rice” for improved information granularity. We intentionally included items people might be mistaken about. For example, walnuts are rich in fat, but in KDRIs they are included to the Meat group as they also contain protein. The photos and labels (“Tomato, 100g”) also exemplify the recommended weight and volume of a serving (Figure 7, right).

(4) Information on hydration: In response to the confusion caused by the Food Balance Wheel (a water cup in the front wheel), a text description of recommended daily water intake in liter and a cup image is added on the right side (Figure 6), to clarify how much water you need, and whether that includes water from food and beverages (soup, juice, etc.).

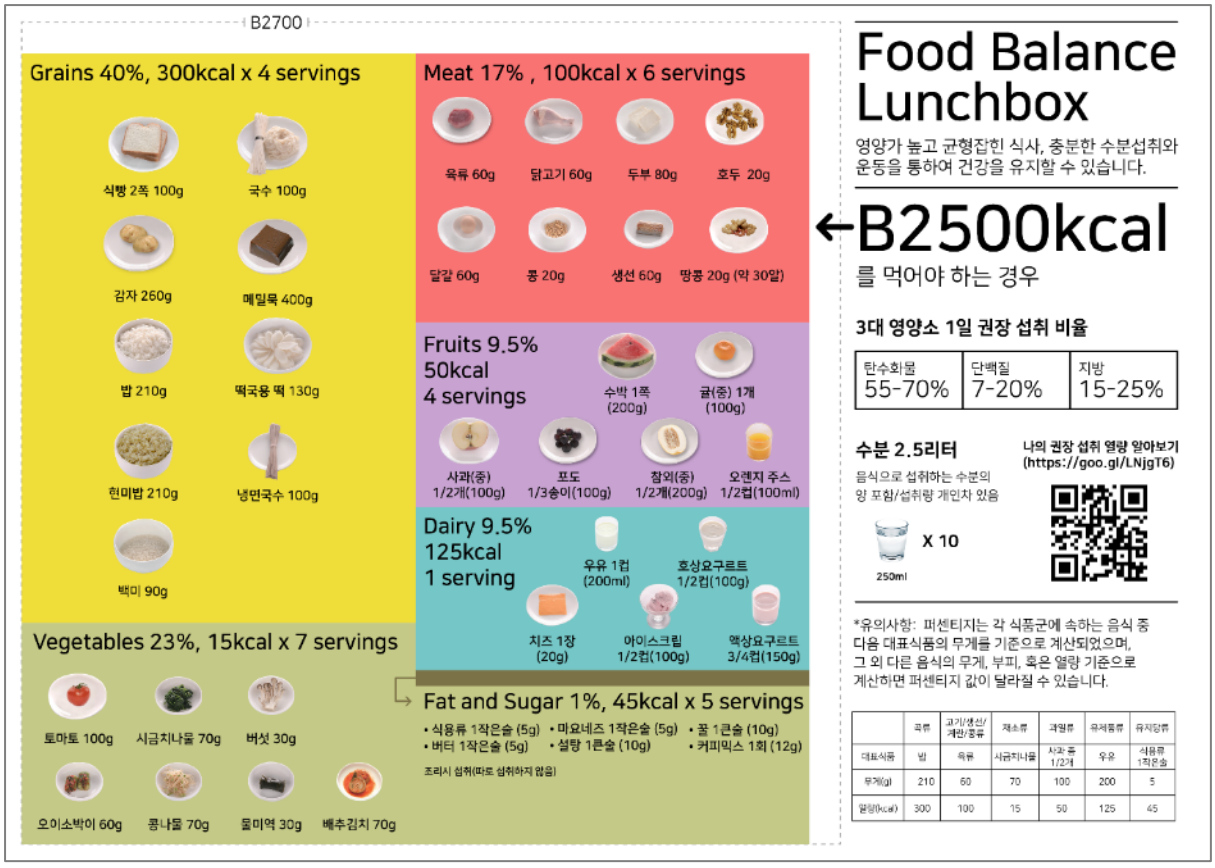

Figure 6. Food Balance Lunchbox: an alternative Korean FBDGs designed in the CCW treemap format. The text is partially translated from Korean into English for this paper.

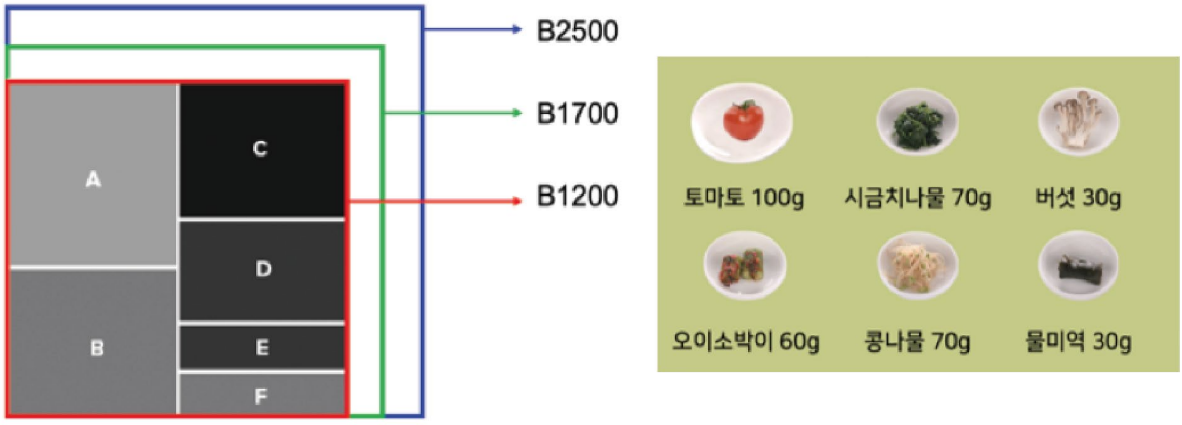

Figure 7. In the Food Balance Lunchbox, different calorie cases will be drawn in different sizes (left), and labelled food photos exemplifying serving sizes in volume and weight are provided.

4 Discussions: Improvements in the Alternative Design

4.1 Format

The biggest problem of current Food Balance Wheel lies in the pie chart format where proportion judgments (i.e., estimating the size of one element relative to the whole) and comparison judgments (i.e., comparing the size of two elements to judge which one is larger) are difficult, compared to other chart types (Huestegge & Pötzsch, 2018). These two tasks matter in that they are part of the audience's cognitive process of reading proportionality (i.e., how much you should eat from each food group per day). For Food Balance Lunchbox, we considered column chart and constant-column width treemap formats that are proven performing better than pie charts in length/area comparison, label alignment, space efficiency, and scalability.

The column chart (Figure 5, center) allows for quick one-dimensional comparison of length and easy label alignment. The white space created on the upper space can be utilized to accommodate more text information. In comparison, the treemap consists of rectangles of different areas, so two-dimensional area comparison is required, but still treemaps are proven to perform better at both proportion and comparison judgment tasks than the pie chart, as well as providing a natural label reading pattern than the circular array of labels around a pie chart (Huestegge & Pötzsch, 2018). As treemaps are rectangular in shape, their space efficiency is high and more information (food photos and labels, e.g.) can be inserted in the slices.

The CCW treemap (Figure 5, right) is a square-shape chart that comes with the benefits of column, pie and treemap charts altogether: (1) it allows for the ease of one-dimensional length comparison of a column chart, (2) it hints on "additional visual anchors for proportion judgments" such as a quarter, a half as is in a pie chart (Huestegge & Pötzsch, 2018, p.213), and (3) the high space efficiency of a treemap that allows for easy labelling and food photo display.

4.2 Concepts

In the Food Balance Lunchbox, **diversity, proportionality, moderation- personalization, and hydration** are better presented, compared to current Food Balance Wheel.

Diversity is illustrated in detail with various items in each food group. Food photos exemplifying serving sizes make the message concrete and actionable. As Montagnese et al. (2015, pp. 909-910) reported, in the world's FBDGs, the diversity concept is depicted on different abstraction levels. American, Italian and Hungarian FBDGs only present food group labels ("cereals", "milk", e.g.), so no efforts are made to exemplify food groups. The Finnish circle shows a typical public lunch catering meal of potatoes, fish, and vegetables served on a plate to contextualize the information better. German and UK models show specific food items in each food group.

In the Food Balance Lunchbox, the authors went a step further and visually exemplify a serving of each food item for improved **information granularity**, e.g., to distinguish *steamed white rice* from *steamed brown rice* (the latter contains more fibre and micronutrients and recommended as a better choice), and such a decision is grounded on the findings from an Australian qualitative study with 85 participants (Talati et al., 2017) that subjects in various

age groups preferred realistic photo images of food to cartoon-style drawings, because “you can actually tell what they are” (p. 173).

Also, the photos clarify how much steamed white rice is a serving of 300kcal, for **moderation-personalization**. Robinson et al. (2016) report that repeated exposure to large portion (not serving) sizes actually affect what consumers think a normal-sized food portion, and Marchiori, Papies, and Klein (2014) conclude that, due to anchoring effect, participants whose expected serving sizes are larger consume significantly more food than others, but Spanos, Kenda, and Vartanian (2015) conclude that informing consumers on how many servings are in the food portion reduce their food consumption. The authors hypothesize that repeated exposure to correct serving sizes of food can affect how much people eat, by enabling visual estimation of whether they are eating more than or less than recommended serving sizes. The concept of **moderation** is also expressed in the model’s (1) customized dimension (e.g., B1200, B1700 and B2500 models are different in areas (Figure 7, left), (2) exclusion of junk food from food examples, and (3) the **personalized recommendation** of daily calorie intake measured in servings (“7 Vegetable servings a day”).

The **proportionality** of six food groups is calculated based on the weight (grams) of a representative food items, instead of their calories, to assist people to estimate better in dining context. Volume is a good visual cue for consumers to know how much they are eating, but accurate volume measurement, comparison, and calculation is difficult for irregular forms of solid food, such as ribs or salad. Visual estimation of food weight in grams is not an easy task either, but the research team hypothesizes that it will be easier than accurately guessing the calories of what they eat. Zhou, Bell, Nusrat, Hingle, and Surdeanu (2018)’s study with 2028 subjects report poor performance on food calorie estimation; “average accuracy was 5 out of 20 correct guesses, where ‘correct’ was defined as a number within 20% of the ground truth”. In conclusion, the print version of the CCW treemap slices are calculated in weight, but the authors are now developing an online version of the model where people can switch units of percentage calculation between weight and calories.

Drinking water is an important part of healthy eating. Drinking water when you feel hungry can let you tell thirst and hunger, so it may contribute to a healthy weight-loss plan. Experts recommend drinking water on a schedule (“Hydration: Why It’s So Important.”, 2017). For **hydration** information, the problematic and misleading water cup in the Food Balance Wheel is replaced with more detailed text description on the right side. Comments on personal differences are added because each person needs different amounts of water to stay hydrated, and the difference between drinking plain water and indirect drinking from food is mentioned to call attention to the extra calories from sugary drinks and fruits.

5 Conclusions and Future Studies

In this study, the authors developed an alternative model of Korean FBDGs, Food Balance Lunchbox in the CCW treemap format, for improved communication of healthy eating for consumers. With the new FBDGs, we expect consumers living on currently unhealthy diet to accurately perceive (1) the concept of personalized dietary patterns, proportionality between five food groups and three macronutrients, food serving sizes, and hydration, and (2) eating healthy as something fathomable and doable daily activities.

Work done in this study is limited, however, because the Food Balance Lunchbox should be tested in a large-scale quantitative study to be proven helpful. In the future studies, first, another alternative model in the column chart format will be developed. Two designs will be tested in comparison with the Food Balance Wheel in a printed image format, in terms of clarity, memorability, and applicability of information.

Also, to improve on the limitation of a static image, interactive versions of the Food Balance Lunchbox are being developed, where consumers can (1) switch formats between column chart and CCW treemap according to their preferences, (2) switch units of proportionality calculation between grams and calories, to see the resulting changes in slice length and understand how the models work, and (3) customize food items in five food groups to make the list more practical in the grocery shopping and dining contexts.

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Framework for developing a Disaster Resilient Society

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The geographical and temporal span of zones, where life and ecology are exposed to risk of disaster are rapidly increasing. Apart from the severity of a hazard, a society's preparedness and response determine losses, survival and recovery, particularly during the critical first 72 hours. Most existing approaches focus on behaviour or management systems that are deployed after a disaster, and not in daily life prior to disaster. Nor do they provide a methodology for developing such systems. We propose a framework for developing a disaster resilience society (FDDRS). Its basis is a detailed, retrospective analysis of three projects aimed at developing disaster resilient systems. Its structure is derived from existing user-centric design methodologies.

FDDRS includes novel methods, like coupling, and existing methods and concepts such as redundancy and modularization. It is unique in its focus on including users and other stakeholders throughout the process, and in advocating dual-functionality and decentralization of infrastructure and services. FDDRS facilitates the development of systems that ensures their applicability in daily life. This is expected to result in a more intuitive, i.e., faster, response to a disaster, thereby reducing a community's vulnerability and improving the chances of survival and recovery.

Keywords: Disaster Resilient Society, Framework, Decentralization, Design Methodology, Engineering design process

1 Introduction

Unprecedented changes in our climate have led to the spread of events that are disastrous in numbers and magnitude, and the trend shows further acceleration. According to The World Bank "over the past 30 years, more than 2.5 million people and almost $4 trillion have been lost to disasters caused by natural hazards, with global losses quadrupling from $50 billion a year in the 1980s to $200 billion in the last decade. 2017 marked an even more alarming milestone in this trend, with $330 billion in global losses from adverse natural events" [1]. Many areas which previously were not in potential disaster zones have lately witnessed serious threats to life and ecology (Guha-Sapir, Hoyois, Wallemacq & Below, 2016).

The risk of a natural hazard causing a disaster not only depends on the severity of the hazard, but also on the vulnerability of a society. In order to abate serious consequences, a

[1] https://www.worldbank.org/en/topic/disasterriskmanagement/overview

disaster resilient society is paramount. Society's preparedness and response determine survival and speed of recovery. In particular, the first 72 hours after a disaster are critical since those affected often have to rely on themselves until emergency services arrive (Public safety canada, 2013). The US National Institute of Standards and Technology found that a society which is trained and prepared for disasters is less vulnerable, less likely to experience disruption, less likely to suffer loss of lives, and is able to recover faster (NIST, 2016a; NIST, 2016b). It is important that reconstruction is: robust, so that assets and livelihoods become less vulnerable to future shocks; fast, so that people can get back to their normal life as early as possible; and inclusive, so that nobody is left behind in the recovery process (Hallegatte, Rentschler, & Walsh, 2018).

A large amount of work exists to reduce disaster risk (NIST, 2016a; NIST, 2016b; NDMC, 2017 & Abarquez & Murshed, 2004) have mainly focus on the development of dedicated infrastructures, such as evacuation centres or shelters to be deployed after a disaster. Not only can these infrastructures be expensive and time consuming to deploy as they are sometimes not available where needed (note the importance of the first 72 hour). Often such dedicated structures are effectively single use structures or services that will normally be under-utilized - or not used at all - and rare use leads to unfamiliarity among its potential users. Moreover, the consequences of failure of the proposed solutions is hardly addressed, if at all, even though this can exacerbate the disaster and recovery. The breakdown of centralised systems such as communication networks, power and water supplies, and transportation systems has grave consequences, as they cannot be restored locally. Recent frameworks and guidelines for disaster preparedness do emphasize the importance of developing community resilience and involving users (Abarquez & Murshed, 2004).

We propose a Framework for Developing a Disaster Resilient Society (FDDRS) based on a detailed, retrospective analysis of three projects conducted over the past five years by the Urban Risk Lab aimed at developing disaster resilient systems. These systems include infrastructure, organisation, services and other elements, as it is a combination of elements that ensures resilience. The projects were chosen because of the underlying unique vision on developing disaster resilience and managing disaster risk.

Systems for disaster preparedness:

- should not just be for use after a disaster has struck, but also play a role in daily life;
- should be able to withstand a natural hazard and function in the event of a disaster;
- should be co-created with the local community, i.e. users should be actively involved in all stages of development, from ideation to use and maintenance to ensure inclusiveness, usefulness and familiarity;
- should allow maintenance and restoration with local competences, tools and materials, and function.

In this paper, we outline the framework and its methods, emphasizing the methods that are specific to reducing disaster risks. In Section 2 we review existing approaches for disaster risk management. Section 3 describes the research methods used to analyse the three Urban Risk Lab projects. The results are presented in Section 4. In Section 5 we reflect on the framework and outline future work.

2 Review of existing approaches for disaster risk management

The UN's report "Living with risk" (UNISDR, 2004) emphasises the need for a disaster resilient community. In the "Sendai framework for Disaster Risk Reduction," the UN proposes a set of guidelines at an international level. The framework highlights the importance of protecting and strengthening resilience across people, communities and countries, and recommends anticipating and planning the reduction of disaster risk to intricate eco-systems, such as "livelihood, health, culture heritage and socio-economic assets" (UNISDR, 2015, p.10). The Association of Southeast Asian Nations strongly encourages participation of local community (ASEAN, 2016).

A variety of other approaches, frameworks, guidelines and recommendations differ in levels of detail - from general guidelines to dedicated processes - and focus - from infrastructure robustness to community preparedness.

Table 1 enumerates four frameworks that are relevant for us as they focus on reducing risk by developing community resilience through a combination of infrastructure and non-infrastructure solutions. We looked at: a) size of system: large (national or global), medium (regional or urban), small (communal or individual); b) type of proposal: process description or guidelines; c) approach: centralised or de-centralised; d) site specificity; and e) level of user involvement: high (from planning to development and beyond), medium (from need finding, evaluation of prototype to testing of the final solution), and low (restricted to need finding and testing of the solution).

Table 1. Frameworks and guidelines for disaster risk management

	Features				
	Systems	***Proposal***	***Approach***	***Site specificity***	***Community involvement***
Community resilience planning guide for buildings & Infrastructures systems (NIST, 2016a & 2016b)	Large	Process	Centralised	National (U.S.A)	Medium
Myanmar national community resilience framework (NDMC, 2017)	Large to small	Process	Centralised	National (Myanmar)	Low
National preparedness system (FEMA, 2011)	Large to small	Guidelines	Centralised	National (U.S.A)	Medium
***Community Based Disaster risk management (CBDRM) (*Abarquez & Murshed, 2004)**	Small	Process	N.A	International (South east Asian Countries)	High
City Resilience Framework (CRF) (Arup and the Rockefeller Foundation, 2014)	Medium	Process	N.A	International	Low

The US NIST planning guide (NIST, 2016a; NIST, 2016b), proposes an interesting 6 step process with a focus on community resilience for built environments at the local level. Performance goals are informed by the needs of local residents and social institutions. The built environment includes buildings and infrastructure systems for power, communication, water, transportation and waste. We note that a critical point of such infrastructures is their scale and transferability: too costly for many countries and sites; too time consuming to plan and build, and inherently inflexible for use in rapidly changing situations; and, as mentioned earlier, failure of such systems critically affects recovery. Interestingly interactions between "natural capital, built and physical capitals, as well as financial, economic, human, social, political, and cultural capitals" are not addressed. These interactions have a compounding impact on risk magnitude and thus on risk reduction strategies.

Myanmar's National Disaster Management Committee (NDMC, 2017) framework describes an inclusive process to reduce risk at the household and community level, with three objectives: promote a common understanding among stakeholders; propose coherent approaches with community and rural development; identify potential opportunities for implementing measures to strengthen disaster resilience. However, the sectors on which to focus are predefined, such as rural livelihoods and village, infrastructure, and urban development, limiting the spectrum of possible solutions. The framework also discourages stand-alone projects, as they are expected to be non-scalable. Independent, local solutions, however, may work when the network inherent to the centralized systems fails.

The US National Preparedness System (FEMA, 2011) outlines a national initiative aimed at developing capabilities and resources "across the whole community to prevent, protect against, mitigate, respond to, and recover from the threats and hazards that pose the greatest risk"(FEMA, 2015, p.1), such as natural disasters, acts of terrorism, and other disasters. Various tools and resources are made available. Potential indicators and measures of community resilience are under development. NPS includes the National Disaster Recovery Framework (FEMA, 2016) that provides principles for recovery and responsibilities of recovery coordinators so that the communities can rebuild faster and safer. Individuals and communities are kept informed and can comment on the documents.

The Community Based Disaster Risk Management (CBDRM) approach, which focuses on south east Asian countries, actively involves communities at risk in the identification, planning, implementation, monitoring and evaluation of risk reduction strategies (Abarquez & Murshed, 2004). CBDRM also addresses socio-economic issues linked to risk reduction measures, such as gender, poverty, poor governance and discrimination. However, the focus in more on proposing a "conceptual framework" for community participation in order to train and actively engage them in assessment and management processes. It does not provide a systematic approach and details of how to exactly develop strategies and reach up to a practical solution.

The city resilience framework (Arup & the Rockefeller Foundation, 2014) consists of 4 categories: health and well-being, economy and society, infrastructure and environment, and leadership and strategy, to complement the development of a resilient city through proper assessment of resiliency, identification of critical areas and needful actions in those areas.

In addition to these five approaches, the set of 18 principles and practices for disaster risk reduction (DRR) formulated by John Twigg (Twigg, 2015) are relevant for our work. He derived these from a review of experiences and practices with real projects. Such a list can obviously never be exhaustive given the varied nature of disasters and contexts in the reviewed projects but is nevertheless very useful. We strongly believe, however, that it requires the embedding of principles and practices in a structured approach to effectively reduce disaster risk.

Based on these notable contributions, we conclude that all focus on behaviour or solutions to be deployed during or post disaster, not as part of daily life prior to disaster. As mentioned before, this leads to unfamiliarity with the solutions and increases the vulnerability of individuals and communities, leading to a slower response and a larger impact of the disaster in terms of losses and recovery time.

The experiences of the Urban Risk Lab team led to an approach that attempts to address the aforementioned concerns. A study of three projects provided detailed insight into the application of and experiences with the evolving approach. The results of the case studies formed the basis of the framework we introduce in this paper.

3 Data collection and analysis of the three case studies

The three project that have been analysed are the following (see Table 2).

1. Haiti: In this project a national strategy in form of 9 evacuation systems, for 3 different sectors (education, economy and transportation) and 3 different topographies each, were proposed across Haiti. Multiple and flexible options for evacuees during emergencies were generated involving natural infrastructure to support risk-reduction and recovery. It particularly emphasizes the principle of accessibility through mobility and landscape.
2. PREPHub USA: The emergency preparedness hubs (or PREPHub) (Mazereeuw & Yarina, 2017) developed in this project aim to integrate disaster preparedness and response technologies into public infrastructure by activating surrounding spaces with useful lifestyle functions. In doing so the PREPHubs offer day-to-day community focal points and, hence, familiar points in case of disaster when they offer access to information, communication and electricity while being entirely off-grid. Prototypes were installed in different US cities.
3. PREPHub Nepal: This project aimed at translating the PREPHub concept to Nepal, where a historical Patti - a traditional community resting space – was converted into a PREPHub.

Table 2 Summary of three case studies.

Case study	***Project Goal***	***Natural hazards***	***User involvement***	***Project status***
National System of Disaster Evacuation Parks across Haiti	System with building and landscape infrastructure concept for longer period (evacuation and shelter, for long periods)	Hurricane, flooding, and earthquake	Medium	Conceptual design of strategies for sustaining systems
PREPHub USA	For preparing and recovery by disseminating information and providing tools to be used regularly. For shorter periods (72 hours w/o shelter)	Earthquake	Low	Prototypes (versions 1.0, 1.5, 2.0 and 3.0), tested on-site with users
PREPHub Nepal	Preparation and recovery for 72 hours using a converted traditional shelter	Earthquake	High	Complete infrastructure embedded into old structure

The project teams used and mentioned different approaches in each of the projects: no theoretical framework exists. We therefore chose Grounded Theory (GT) (Strauss & Corbin, 1994) as our approach.

3.1 Collecting Data

Data was retrieved by analysing all available project documents, such as journals, reports and log books. Semi-structured interviews with the project leader provided data about the sequence of activities, when this was not clear from the documents. We used 5WH questions to understand the core process because of its effectiveness in identifying the steps and activities, and their interconnections. Once patterns began to emerge, questions were asked about reasons behind transitions and decisions. A total of 14 interviews (700 minutes in total) were conducted over a period of 6 months, some of which involved multiple

projects. Data on Project 1 was collected in 5 interviews, on Project 2 in 4 interviews, on Project 3 in 5 interviews and on other projects in 5 interviews, and evaluation of emerging process was done in 6 interviews. The interviews were audio recorded for ease of analysis.

3.2 Arranging and Coding Data

Grounded Theory based open and axial coding techniques were used. Open coding assists in generating categories (codes), classifying phenomenon and inferring meaning from large data set by segmenting and identification of repeating questions like "what is this about? What is being referenced here?". Axial coding uses inductive and deductive thinking to relate codes with each other and reveal themes (Strauss & Corbin, 1994)

Data from the documents was labelled and organized chronologically as an activity diagram for each project. Relevant pictures were linked to the respective data. Most of the interviews used these diagrams or the reports to obtain a deeper understanding, answer open questions, or link data. Data from the interviews was then added to the diagrams and – where necessary – existing data in the diagrams moved or removed. Once data was collected and arranged, repeating activities were identified and coded using terms describing the activities of the team. The code-set became richer with the analysis of successive case studies, and recurring terms were identified, e.g. site-contextualization, region characterization, or risk profiling, were found to be used frequently across projects. The case studies involved expertise from diverse domains, which further enriched the set of codes and concepts. The coded data was grouped into concepts, which – once they were arranged chronologically – revealed the underlying process followed by the project team.

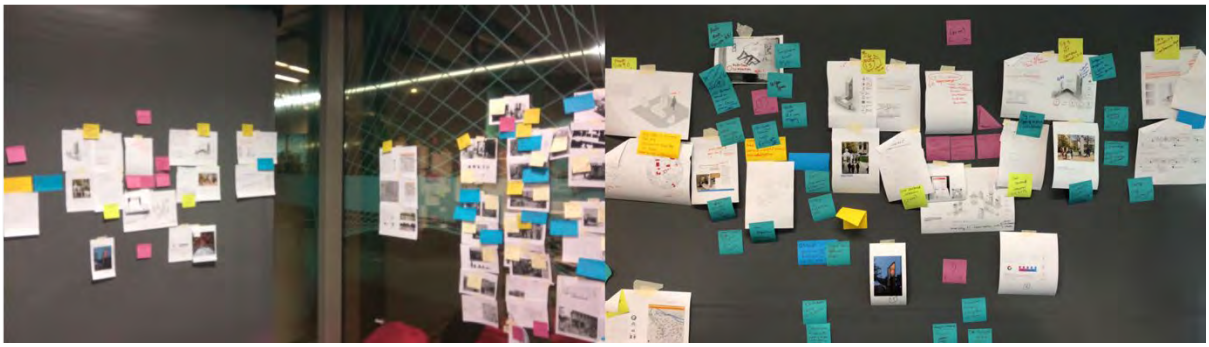


Figure 1. Part of the chronologically arranged data collected on Projects: PREPHub Nepal (right) and PREPHub USA (left)

3.3 Analysing Data

Using the codes and concepts developed in the previous step, we were able to identify inherent structures in the three projects. A cause-effect analysis was performed to better understand the differences and communalities between the projects, the reasons of changes within the projects, and the process flow. Intentions, reasons and consequences of the captured decisions were analysed, as well as the methods and guidelines that were used. This led to a set of preliminary guidelines and some indication of which process steps and activities seem useful under which circumstances.

3.4 Framework structure

Our aim is a framework and a related set of methods and guidelines, which can be used to design solutions for a resilient society. In order to develop a framework onto which the identified processes, concepts and steps can be mapped, discipline and topic specific design methodologies were studied, in particular user-centred methodologies. We adopted the

cross-disciplinary comparison-based model by Gericke & Blessing (2012), and the phase definitions and methods of Pahl & Beitz (2013) for the mapping process. Contextualisation, which we found to be a particularly important step, however, did not appear explicitly in these design methodologies. We added it as a separate phase.

4 Development of the framework and its components

The results of the case studies formed the basis of the framework we introduce in this paper; an analysis of existing user-centric design methodologies provided its systematic structure. The proposed framework aims to provide a systematic and adaptive structure to facilitate the development of systems whose location and functionalities allow them to be part of the daily routine of people in the respective community. This is expected to result in a more intuitive, i.e. faster, response to a disaster, thereby reducing a community's vulnerability and improve its chances of survival and recovery and contribute to society's level of preparedness and resilience to disasters.

As discussed in Section 3, this framework is a combination of different elements. Here we focus on guidelines and methods derived from the case studies.

We identified several design approaches used in the case studies. Some were prominent in one case study and some in another. Together they shaped the strategies at local level:

- Participatory system: Partners and stakeholders were involved from the beginning even before finalising the project goal, to learn from and incorporate their strengths, knowledge and experiences in generating solutions and obtaining feedback.
- Bottom up approach: Local leaders and users were actively involved in identifying core problems and deciding risk strategies, supporting localisation of the solutions (see also Victoria, 2002).
- Coupling process: Systems were developed for use in daily life as well as in case of disaster (and not only in case of disaster) in order to help users familiarize with these systems, develop intuitive usage and greatly enhance the usage of the system. Two forms were identified: adapting existing systems for use during and post disaster or creating new disaster management systems that can also be used in daily life.
- Distributed network: The systems were local solutions, but suitable or adaptable to other locations (as PREPHub showed) in order to make a community less vulnerable to break-down in the case of a disaster than the networks of large central infrastructures.
- Redundant and Modular design: For critical needs multiple ways to achieve one function (redundancy) using different working principles were embedded in the solution, e.g. on grid and off grid use to ensure core functions even if the central (grid) system fails during disaster as proposed by Morrish (2008). System modularisation has the same aim, allowing switching between sub-systems in case of failure of one or more subsystems (Allan & Bryant, 2011). Modularisation also allowed the adaptation of the system for other locations.

Figure 3 shows the first version of our framework, its phases and steps. The aim is to bring together and structure existing methods and tools as well as those that were developed by the Urban Risk Lab. The process is not linear as various steps are closely linked, within and between phases. Iterations are essential in any development process: many studies showed

that problem understanding and ideation co-evolve. Moreover, the relevance and importance of the individual steps, methods and tools must be determined in line with the context and situation at hand: “opportunistic design styles are not only more common but are also significantly superior with respect to design performance” (Bender & Blessing, 2004, p.5). The inclusion of these steps, methods and tools in the framework ensures that the relevance of the issues they address are considered. The framework also emphasises the need to consider implementation, use, maintenance and end-of-life.

Each of the phases will be described in more detail below. The focus is on the early phase and its steps, as these are found to be the most critical and most differentiating from other such frameworks and methodologies.

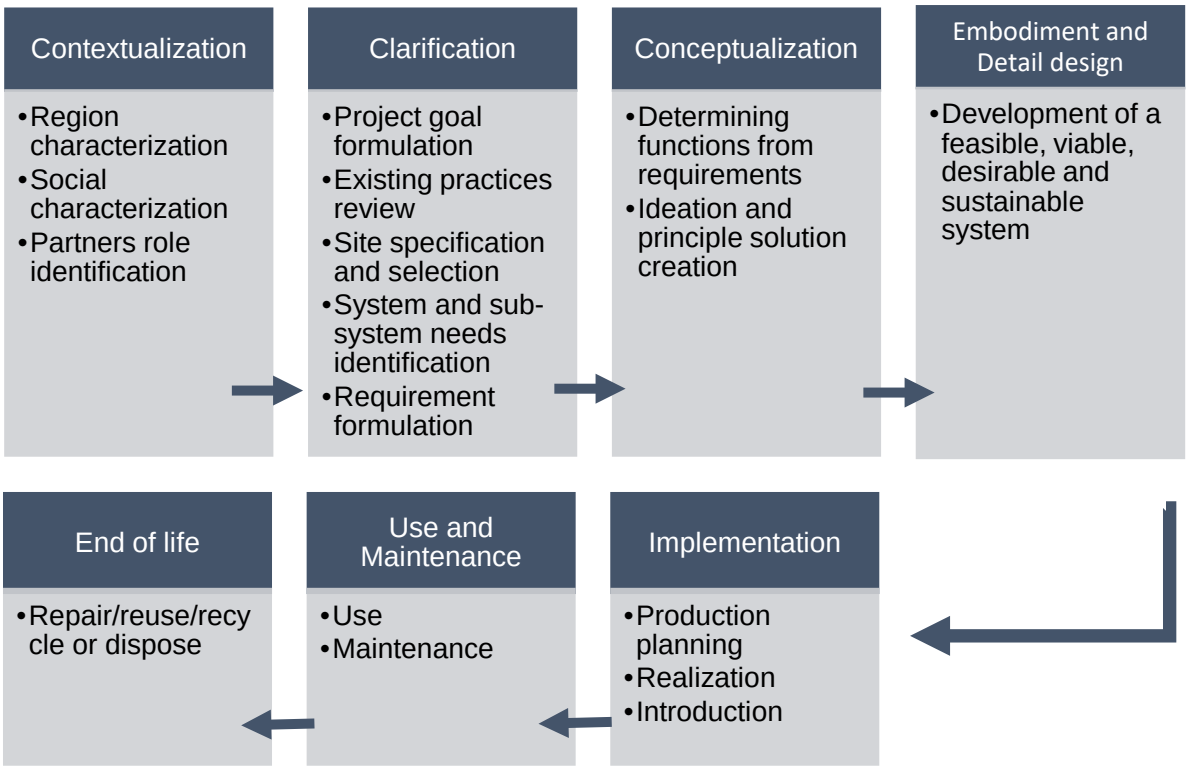


Figure 2. Framework phases and steps

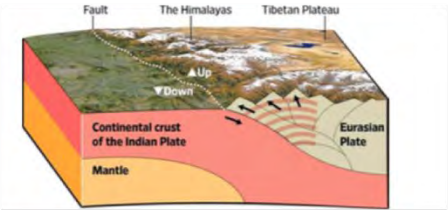
4.1 Contextualization:

By including a separate phase for contextualization, the framework highlights that for developing resilient societies, contextualisation is extremely important, even before defining the precise projects goals and requirements, unlike typical design processes. Contextualization helps in characterizing the overall project and addresses the current capacity of society in combating adverse situations as we learned from the case studies: one-size-fits-all solutions are unlikely to deliver the integrated solutions that are necessary to deal with disasters. The essential steps we identified are:

4.1.1 Regional characterization (see Fig 3A and B): It is important to develop a holistic view of how regions are divided, densified and developed to identify type and magnitude of risks and their management. This includes a proper understanding of how the region transforms when exposed to risks, how the local economy functions and what the risks are to social, cultural, economic and environmental pillars in case of a disaster.

4.1.2 Social Characterization (see Fig 3C): An in-depth understanding of the region (local society) is required, particularly with respect to its preparedness and response to crisis in the past. This should include information about involved organizations, local governance bodies, persons in-charge, youth forces, etc. We need to consider awareness among locals, communication points for media, literacy rates and list down social resources. Furthermore, the relationship of these elements with economy, market, school, culture, society leadership and institution should be identified.

4.1.3 Partners characterization (see Fig 3D): Formal and informal collaborations with local people and organizations play a crucial role in understanding the contexts of the risk and in designing a locally fit solution. Early partnership with local governments helps in connecting with potential stakeholders and in smooth operation of the project and ensures the solution considers local strategies, and builds on local knowledge and expertise.



A. Regional characterization

C. Social characterization

B. Regional characterization

D. Partners characterization

Figure 3. Contextualisation phase in PREPhub Nepal (Photos from URL team. Reproduced with permission.)

As shown in Figure 3, the contextualisation phase in the Nepal case study focused on 3 key questions: i) how is the region developed, what are the potential natural risks, and what are previous disaster effects (in this case, post Nepal earthquake 2015 scenarios)?, ii) how is society using the local space and what are their daily and post disaster needs? and iii) which local partners can be involved to successfully develop, implement and manage solutions?

4.2 Clarification:

The clarification phase aims to formulate project goals, select suitable sites and formulate an initial requirement list.

4.2.1 Project goal formulation: Project goal(s) need to be in congruence with the requirements of the local people and incumbent social behavior while considering disaster risk.

4.2.2 Existing practices review: Reasons behind successes and failures of past and current strategies should be clarified, not only with respect to the project location, but also similar regions (based on climate, risk type, topography and culture). This includes urban context (population density and pattern and topography), scale (block, neighbourhood and national) and temporality (short term to long term), as well as the connection with such elements as economy, social resources etc. Integration of local knowledge with scientific expertise is encouraged (Mercer, Kelman, Taranis & Suchet, 2010).

4.2.3 Site specification and selection: The framework advocates development of both infrastructures and services for preparedness and recovery. Hence potentials sites and infrastructures are to be identified that can be points of contact during daily life as well as during and after disasters. The process for selecting the site has been divided in three steps.

1. Map each risk to the type of preferred location in case of disaster, such as open space for earthquake prone areas, and include this into the site requirements list.
2. Identify suitable existing sites through characterisation of infrastructure and buildings from institutional and non-institutional systems such as economic, education, religion, and recreation. Include the possibility of investment in additional buildings or infrastructure.
3. Match the potential site identified in (2) to the required type from (1) by evaluating various qualitative and quantitative factors such as accessibility, visibility, stakeholders and community agreement. The aim is to attempt the use of existing sites first, before building completely new systems to optimize resources and to ensure familiarity of the local population with the site.

4.2.4 System and Sub-Systems needs identification: To enhance usefulness of these sites, local sub-systems should be understood, quantified and taken into account in the process, in particular those which provide essential life resources, which may be affected during disaster scenarios. Interviews with stakeholders help discover everyday needs such as securing water, food, education, life stock, etc. and key needs during disaster. These daily needs are coupled with necessities during a disaster. Coupling encourages active usage of sub-systems in daily life and not only in times of disaster which helps in quick response.

4.2.5 Requirement formulation: The requirements list is completed by including all life-cycle phases, including manufacturing/building, transportation, introduction, use, repair and maintenance, both during normal use, when disaster strikes, during the first crucial 72 hours and during the following recovery period. The requirements list should include relevant laws, regulations, and guidelines for normal and disaster situations (Sphere, 2011).

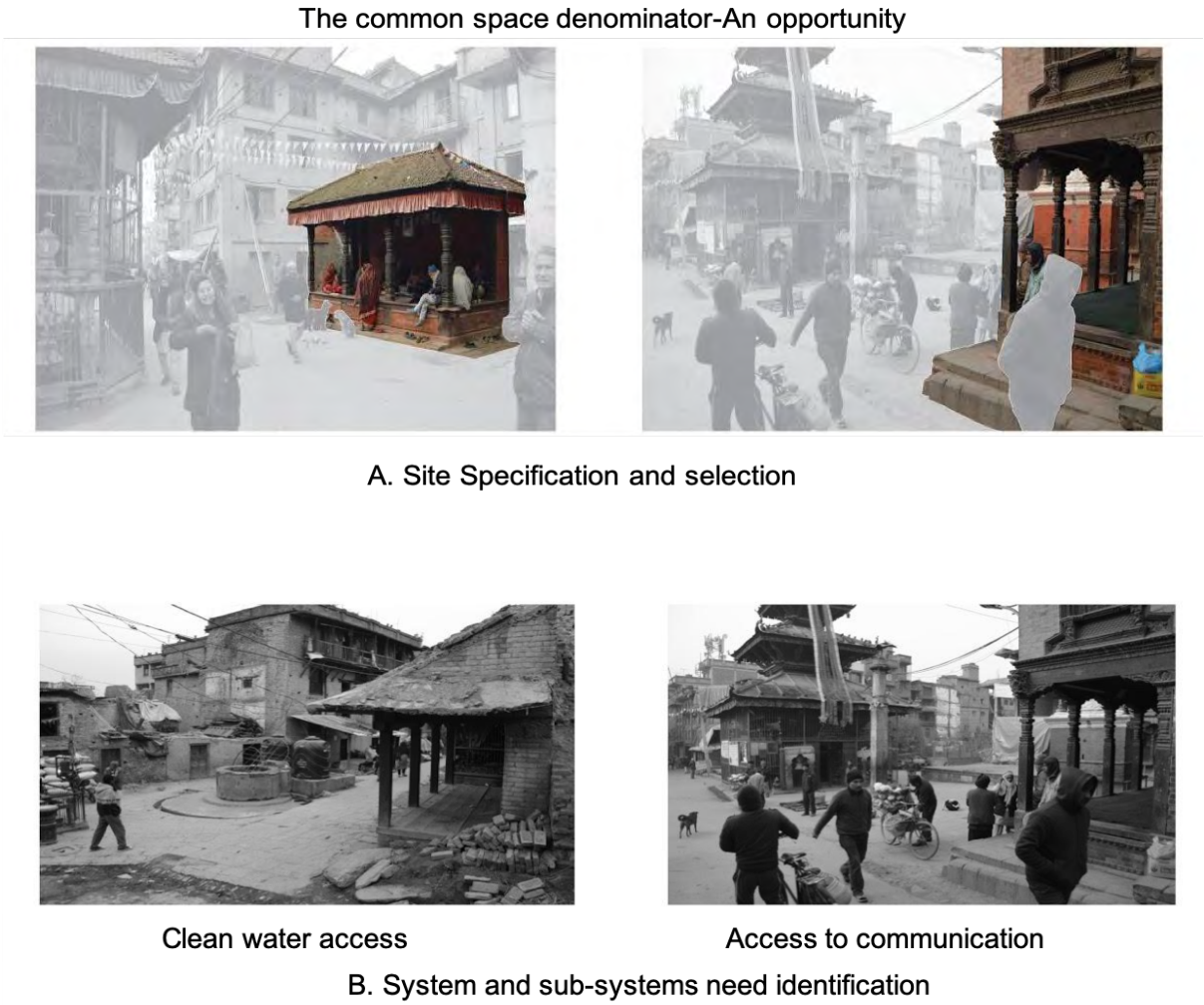


Figure 4: Clarification phase in Prephub Nepal case study (Photos from URL team. Reproduced with permission.)

Figure 4 illustrates (4.A) the site specification and selection phase and (4.B) system and sub-system needs identification phase. Both steps fulfil the needs of community in both daily routines and disaster recovery.

4.3 Conceptualisation

During conceptualisation, the principle solution is created (Pahl & Beitz, 2013). Functions and sub-functions are established based on the list of requirements. Working principles for the functions are selected and brought together into one or more solutions, while considering strategies such as modularisation and redundancy. We argue in favour of a decentralised concept with multiple strategies.

4.3.1 Determining functions from requirements: Functions and functional relationships between input and output of existing and required systems are formulated. The foundation for redundancy and modularity for building resilience are laid in this phase.

4.3.2 Ideation and principle solution creation: Working principles are chosen to realize the different functions, taking into account both normal and disaster related scenarios. Working principle or physical principle redundancy is an important strategy to reduce risks. The working principles are combined into one or more principle solutions.

4.4 Embodiment and detail Design

Embodiment and detailed design stages elaborate the principle solution(s) into user-friendly, technically feasible and economically viable solutions with consideration of safety, ergonomics, production, assembly, transportation, installation, operation, maintenance, recycling, costs and schedules to the point that these are ready for production (products) or implementation (services). Following are some guidelines derived from our case studies:

- Functional design: Design for dual use, for everyday and disaster scenarios for e.g. the PREPHub radio acted as source of entertainment under normal use and a source of critical information during disaster.
- Hedonistic design: Design to draw attention and stimulate curiosity for all type of users in the interest of attracting and encouraging interaction with the system on a daily or at least regular basis.
- User-centred design: Co-create with multiple local generations through workshops, public engagement programs, and other forms of community mobilization to ensure cultural and community understanding of the solution, the inclusion of community preferences, and of the needs of vulnerable people in the community. This affects, e.g. the use of signs or language, or the limitation to certain uses, PREPHub, for example, allows mobile phone recharging, but only as far as required for emergency calls to ensure recharging resources are available to many.
- Prototyping: Develop 3D models, small scale or real size prototypes to understand "how people acquaint themselves with every day and emergency functions, and to improve user comprehension and comfort" (Mazereeuw & Yarina, 2017, p.70).

Figure 5: Interaction of different users with the PREPHub USA prorotype version 1.0 (left) & version 2.0 (centre and right). (Photos from URL team. Reproduced with permission)

Figure 5 illustrates how the design of PREPHub USA encouraged the engagement of different users (old or young) in different forms in daily life. PREPHub is designed such that the system is functional during disaster scenarios as well, e.g. when the electricity grid or internet might fail. Pedal power (central image) is used to charge mobile phones if the power grid fails, yet also works under normal conditions attracting children to the Hub.

4.5 Implementation

Acceptance and approval of partners, users and involved stakeholders is required to implement the solution. This requires their early involvement in the process, i.e. they need to play an active role in the Contextualization and Clarification phases. Then onwards, planning and production can be initiated. Important steps are the identification of construction

partners, local regulations and standards, construction methods, required resources (material, labour), site preparation needs, etc. Working as much as possible with local resources will benefit use, operation, maintenance and end of life.

4.6 Use and Maintenance

The framework encourages active involvement of the community not only in development and implementation, but also to provide feedback and to ensure maintenance. As highlighted earlier, this requires the community to have been involved from the beginning, and the consideration of use and local maintenance during the development stage.

Interviews, photos and videos can provide useful feedback on e.g. how users familiarise themselves and interact with the system, how intuitive the system is to use, how reliable the system is, and what issues have to be addressed in the current or future versions of the system. This requires monitoring over a longer period.

Figure 6: An example of including a local partner (womans co-operative) to maintain the site and quality of water in Nepal PREPHub. (Photos from URL team. Reproduced with permission.)

Figure 6 shows the involvement of local partner and the community in the daily maintenance of the site, benefitting for daily use as well as easy operation during emergencies. The local women's cooperative and a user committee played an important role in maintaining the PREPHub and the quality of the water provided in the PREPHub by leasing water quality test equipment and monitoring quality of water in return for earnings from the sale of water sold by the user committee.

4.7 End of life

Well organised and executed maintenance will extend the life of the system, but eventually the system or its components become ineffective, inefficient or obsolete. Considering end-of-life of the system during the development process, through strategies such as design for recycling and modularisation, has a large effect on the possibility to reuse and recycling, as well as on safe disposal of the system or its individual components.

5 Conclusion and future work

This paper describes the outline of a novel framework (FDDRS) for developing systems to increase disaster resilience in society. This first version is based on a detailed analysis of 3 case studies. The framework is unique in its focus on including users and other stakeholders throughout the system development process and throughout its life, and in advocating dual-functionality (daily life and disaster scenario's) and decentralisation of infrastructure and services. FDDRS emphasises on developing existing infrastructure and strengthening intra-

social relationships. The introduction of existing design process models gives a proper structure to the proposed framework and brings concepts such as working principles.

We plan to test and improve the framework using additional case studies from the Urban Risk Lab, as well as other groups. The studied cases mainly focused on infrastructure and were restricted to preparedness and recovery phases of disaster risk management. More diverse cases studies will be included, such as services for early warning and response phases.

Future work includes the mapping of existing methods for developing a disaster resilient society into FDDRS and the investigation of their relevance for particular contexts and risks. Our initial focus will be on risk and vulnerability assessment methods.

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Happy Chappy Healing House: Can the spaces and environments within a children's hospital be designed to create hope: a case study in Anqing City, Anhui Province, China

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This research paper will propose and design a new children's hospital environment, which inspires hope by creating spaces that feel safe, happy, warm, and even bring joy. The project aims to reduce the fear; fear that manifests in both the patient and the loved ones who visit or stay with them. The architectural psychology of spaces will be combined with design principles of patient-centred architecture, to create environments for physical and psychological healing for younger patients and their loved ones. Using, Feng Shui which has developed over three thousand years to culminate in a design theory that involves ecology, natural phenomena, biophilia, conservation, spatial design, and architecture. There are four fundamental philosophies in Feng Shui: Ying Yang (complementary and balance), Bagua (Eight Diagrams), Wuxing (five elements), Chi (flow of energy). This project will use Ying Yang and Bagua plus the auspicious notion of "san yang kai tai" which literally translates to "three sheep open the harmony world". The principal aim of this research project is to create social hospital spaces that provide a sense of hope and provide a better atmosphere for sick children and their families. Creating modern patient-centred health care spaces may allow people in the hospital to forget for a moment that their child is unwell. While a children's hospital are primarily made up of several medical specialist departments, the implementation of better medical procedures in these areas is not the primary goal of this project. The focus of this project is on the child-friendly environment of public spaces, corridors and non-medical treatment areas of a children's hospital, and how the interactions within these spaces influence the child's (age 2-18) and their family's wellbeing, both physically and psychologically. The experiences of hospital care will leave a lifelong effect on a human being. Can we reinterpret the traditional impression of hospitals as places of diseases, death, and pain in places of hope, happiness, and life?

Keywords: Designing for Hope, Children's Hospital, Social Architecture

1 The context of Anqing City, Anhui Province, China

According to the National Population Statistics of Counties and Cities of the People's Republic of China and World Population Review, Anqing City is a Medium-sized City or Tier III city, which means it has a permanent population of 500,000 to one million. In 1903, the

first Western-style religious and ethnic hospital was founded in Anqing City, by a medical doctor and missionary Harry B. Taylor named the St. James Hospital. The former hospital buildings combined Baroque-style architecture and traditional Chinese architecture, creating the first Western-style hospital in Anhui province at the time. Currently, there are 779 health institutions in greater Anqing City, including 52 hospitals, 291 health centres, four outpatient departments, four clinics, and nine specialised prevention and treatment stations. (Fang 2017) Presently no children's hospital exists, which is specially designed for children with a child-centred design; there are only departments within the general hospitals. It is crucial to improve the health and well-being of children in Anqing City and create a new generation of children's healthcare facilities, which serve as a tool for the city children's healthcare improvement. Anqing City's health institutions have a total of 14,971 beds, including 9,735 hospital beds, 3,996 beds in health centres, 500 beds in the specialised prevention and treatment station, and 156 beds in the maternity and childcare station. There were 1.95 beds in health institutions per 1,000 population in 2017, which is lower than the recommended World Health Organisation (WHO) hospital-bed ratio of 4.5 beds per 1,000 population. It is also lower than the Chinese average hospital-bed ratio of 3.87 beds per 1,000 population. In the 2018 List of 'Organisation for Economic Cooperation and Development countries' Hospital-bed ratio, China is ranked 55th in the world, which is higher than New Zealand, Canada and many developed nations; however, there are never enough beds for the number of patients in need. The reason for this is that the Chinese hospital system accepts all patients, no matter how injured or sick they are.

2 Scope of the Project

While a children's hospital is primarily made up of several medical specialist departments, the implementation of better medical procedures in these areas is not the primary goal of this research project. The focus of this project is on the child-friendly environment of public spaces, corridors and non-medical treatment areas of a children's hospital, and how the interactions within these spaces influence the child's (age 2-18) and their family's wellbeing, both physically and psychologically.

"The image of the hospital as a construction site, coupled with the natural fears of a child in a strange environment, remains ingrained in memory for many of us." (Verderber 2000 p3) Verderber reiterates that the ideal principle of children's healthcare is first to reduce the fear and distract from the pain before the designer focuses on creating a happy and hopeful environment for patients and their family. Roslyn Lindheim in (Verderber 2000 p3) states "The adjectives used to describe hospitals include dehumanising, depersonalising, neutering, frightening, uncaring. "I have never heard anyone describe a hospital as beautiful, peaceful, healing, warm, joyous."

3 A comparison of the New Zealand healthcare system and Anqing City, Anhui Province, China.

3.1 New Zealand

The New Zealand healthcare system is highly decentralised. This decentralisation is by design and aims to reduce loads on hospitals as much as practicable. Hospitals are intended to be used as a specialist critical care and emergency service; to achieve this, non-critical and minor procedures must be dealt with elsewhere.

“If you’re sick and it’s not an emergency, you should visit a family doctor (or ‘general practitioner’– GP)”. Ministry of Health. (2018)

In New Zealand, anyone needing general medical service will usually visit their local general practitioner (GP) clinic. General practitioners are specialists in generalised medicine. People will often visit the same general practitioner for many years, which enables the doctors to build a relationship with their patients and better understand the patient’s health issues over the long term. Alongside GP clinics in the New Zealand healthcare system are Accident and Emergency (A&E) centres, which provide accident and minor urgent medical services, such as non-critical broken arms and legs, as well as after-hours care and x-ray services. Hospitals in New Zealand are free to visit for all New Zealand residents, and are fully equipped to deal with the spectrum of health conditions which are provided by the other areas of the New Zealand healthcare system but aim to be reserved for emergencies and significant non-urgent procedures. Visiting hospitals for minor and non-urgent conditions is frowned upon and actively discouraged. A critical role that hospitals play in providing an emergency medical treatment where the patient is in a life-threatening or unstable medical condition.

3.1.1 Benefits and Downsides

There are benefits and disadvantages to the decentralised medical system seen in New Zealand. The system aims to ensure that all patients are able to receive medical treatment in a timeframe, which is appropriate for the nature and severity of their condition. The decentralisation reduces potential bottlenecks and issues relating to the capacity of particular medical facilities, but also tends to increase the overall length of time taken for treatment. Patients often need to visit facilities which are in different physical locations, which can place an additional burden on those who do not have reliable access to transport. While quality public healthcare is available to all New Zealand residents at no or little cost, there are significant advantages in convenience and wait times for wealthier patients who can pay for private treatment. For the decentralised system to work GP, Specialist and A&E centres need to be able to provide a standard of service that is comparable to that received at a hospital.

3.2 China

The Chinese hospital and healthcare system functions in a fundamentally different way to the New Zealand system as it is highly centralised. There are local community health medical centres, but the hospital is still the first choice when people feel sick. Chinese hospitals function in a way similar to a scaled-up A&E Clinic, with a full range of specialist departments in the one location, rather than the specialist emergency department role seen in New Zealand. Hospitals in China include an outpatient’s department, inpatients department, specialists, lab tests, emergency department, on the one site. All hospitals are operated by the government, which means they all have excellent medical resources. Upon arrival at a hospital, a patient visits a reception desk where they must present their National ID card or social security information. After registration, the patient will then be directed to the appropriate department for their needs. For example, a person with a broken arm would be directed to the Out-patient Surgery Department; someone with a chest infection or breathing problems would be directed to the Fever Clinic Department. These separate departments have doctors and equipment specialised to that particular health condition. After arriving at the correct department, the patient will wait to be seen by a doctor. If a patient needs to then go to another department, this process of going to the correct area and

waiting can be repeated several times. Due to the large population and highly centralised nature of the system, waiting areas are generally overcrowded. Patients and their families can spend a long time waiting, while their time with the doctor can be woefully brief: this can lead to people feeling frustrated and dismissed; even if the doctor has done everything from a technical perspective to deal with their problem.

3.2.1 Benefits and Downsides

The centralised system used in Chinese healthcare is fundamentally different from that in New Zealand. The Chinese system is very efficient concerning the density of medical facilities found in one location where one can get access to a full range of high-quality treatment and facilities on the same day at the same location. Having access to multiple specialist departments and a full range of state-of-the-art medical equipment in the same building is a significant benefit. However, the Chinese system is highly inefficient concerning the amount of time spent at the hospital, compared to the amount of time spent being treated. Much like the experience of visiting an A&E clinic in New Zealand, the Chinese system has extended periods of waiting before and after registration and before seeing a doctor. This "dead time" where the patient is waiting around without anything else they can be doing and is found to be very frustrating. Delays because of bottlenecks in the system, such as in the registration areas and insufficient doctor numbers, can be quickly and commonly further compounded by fluctuations in patient numbers. A benefit of a centralised system is quality control. Having all the facilities in one location, particularly in a field such as healthcare which is overseen by the government, allows for much easier standardisation and regulation of the quality of treatment, so the public feels confident that they will be receiving a high level of care.

3.3 How the New Zealand System Could influence the Chinese System

Completely reconstructing the Chinese healthcare system is firstly entirely unachievable and also vastly outside the scope of this project. It is also unclear if such drastic changes would be beneficial. Lower infrastructure requirements and quality control are significant factors in the healthcare system, particularly in developing countries such as China. However, this does not mean that there is little to be learned or gained from applying the ideas of a decentralised system to China and adapting them to work within the existing environment. Utilising the architecture and the design of the spaces within the hospital facility, there is potential to mimic the effects and results of a decentralised system within a single building. One theoretical example of this could be to separate the main registration area into two areas, providing one reception area for patients who are just visiting for a regular check-up (E.g. regular blood pressure checks) and having another registration area for all the other patients who have new or more severe conditions. This division would help to disperse crowds and reduce wait times, as well as allow the system to become more efficient, as each area can be specialised towards the types of patients who come to them.

4 How to Create for Patient-Centred Healthcare Looking at patients as individuals

Purves (2009 p76), posits that hospital care should be focusing on the care of the patient as an individual. "The view of patients as consumers, linked with the concept of customer care is bringing about many attitudinal changes to how medical services are delivered." In his book, he raised the idea that art and environment heal people slowly, and according to Ernst Dimnet within Purvis (p77), "Architecture, of all the arts, is the one which acts the most

slowly, but the most surely, on the soul." Moreover, he postulates that environment design affects patients' treatment. "The ethos of the building will become an important starting point to achieve environmentally well-designed buildings that can offer therapeutic benefits to patients, as well as all of the users of the building." (Purves p10)

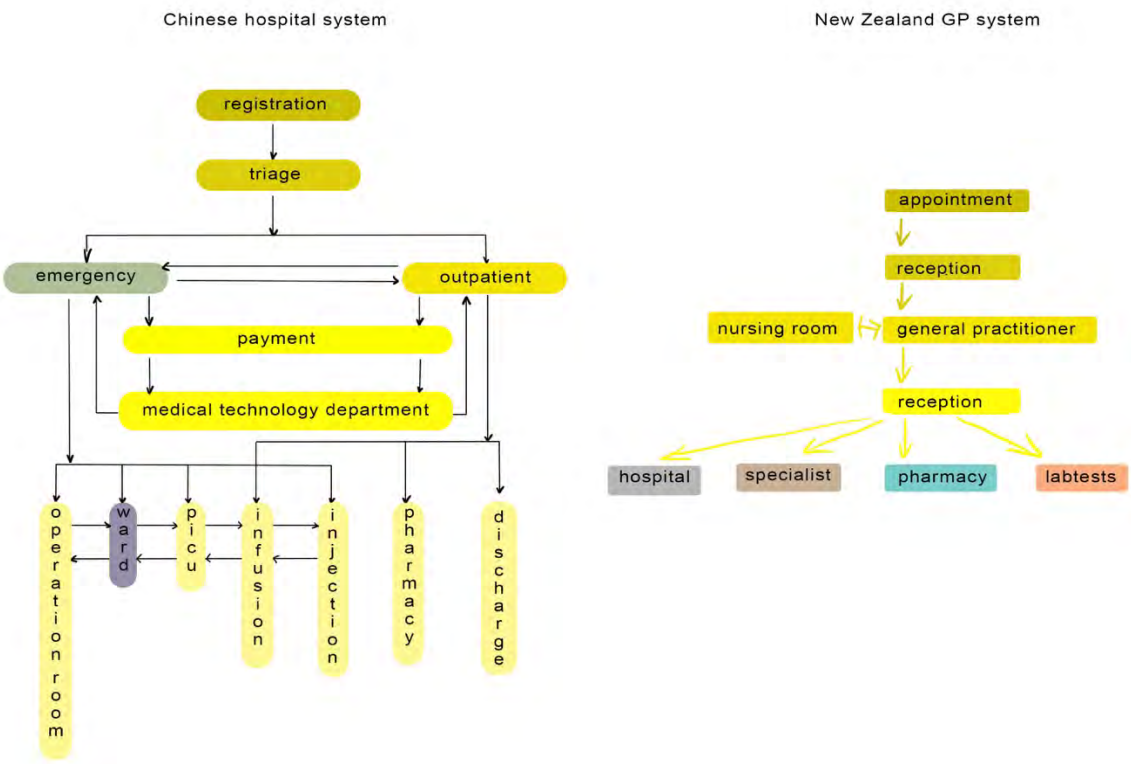

Figure 1. Comparison of Chinese Healthcare system and New Zealand Healthcare

The patient is the key, and the architecture design should focus on patients' need. Therefore, a children's hospital should be child-friendly and suit different child phase from new-born to eighteen years old. Kenneth C. Calman within (Purves p35) states "The patient is at the heart of the process and thus the environment within which they are cared for critical."

Christopher Day (2004) emphasized how children need different environments compared to adults. *"Harsh, immobile, imagination suppressing surroundings are hardening and damaging to children's growth. They need soft, fluid and wonder-filled places for their imaginative world to blossom. (a play alcove, with coloured glass window, for four to six-year-olds)".* Day attaches weight to the belief that children have different needs of environmental design, based on their different ages. "Younger children (new-born to twelve-year-olds) and older children (thirteen-year-olds to eighteen-year-olds) will be different not just physically but also the way they think about the world." They have different needs of the spaces. One needs things to be lower and more vibrant colour. Another needs more explanation, rich sensory experiences and delightful spaces. Younger children subconsciously connect with their surroundings and experiences; therefore, nature, art, and colours (p 217)

4.1 The Patient is Not Just the Child

When thinking about the design of a children's healthcare facility, it could be logical to think only of the specific needs of the patient. However, this line of thinking is overlooking one major factor. Children (particularly younger ones) are dependent on their families; dependant on the food, shelter, protection, and loving care that families provide. This bond is even more significant than just healthcare, and it is core to the very survival of humanity. When considering the positive effects and design implications of patient-centred care in a children's hospital, it, therefore, seems only logical that to receive the maximum benefit from this style of design the scope of the "patient" should be broadened to include the child's immediate family. If a child patient is happy, but their family is exhausted, worn out, uncomfortable, hopeless, and full of fear, this would not be expected to achieve the desired result, especially when considering the role that family plays in the long-term health outcome of a child.

4.2 Child Scale

Mark Dudek suggests listening to what children have to say about their daily life, then getting essential details from them as the key to designing their spaces. In his research, he mentions that children have limited knowledge of space, so experiences, visual connection, and their physical engagement with the environmental impact on their sense and understanding of the places. (Dudek 2005 p8)

4.3 Hope in Healthcare

"Hope is an optimistic attitude of mind based on an expectation of positive outcomes". More than just being something, which is nice to have, research has shown that hope has a range of significant and influential benefits. Profoundly hopeful individuals have been found to perform better in "athletic, academic, occupational and health outcomes." (Dockray 2010) It is thought that this is likely due to a positive relationship between hope and mood. It has been well documented that one's mood has a direct effect on physical health, such as immune system response and cardiovascular function. (Dockray 2010) Hope has a positive relationship to higher overall life satisfaction, with hope also acting "as a buffer against the impact of stressful life events" (Valle 2006) resulting in people being happier overall and staying happier for longer in adverse situations. In terms of the connection between hope and children's healthcare, a relationship has been seen between children's experiences with the healthcare system as a child, and their hope and optimism as well as overall health outcomes as an adult. Those who had negative experiences as a child were found to be less optimistic and have poor healthcare behaviour as adults. (Jones et al. 2008) Children who have high levels of hope have also been seen to tolerate pain better (Synder 2005) and be more likely to follow the instructions of a doctor. The optimistic attitude inherent in hopeful individuals plays a crucial role in successfully coping with a medical illness and its prognosis, as well as in improving health-related quality of life. It is, therefore, essential to consider hope when designing health care facilities.

4.4 Special Considerations for China

When designing architecture in China, there are specific issues that have unique or increased importance when compared to how one might design in the western paradigm. These issues range from specific medical requirements to dealing with cultural differences, family structures, and cultural norms. In China, there is currently a specific focus on children's healthcare. China is still a developing nation and, despite making rapid improvements and advancement in economic prosperity and healthcare, there are still issues that disproportionately affect developing nations, which need to be addressed. In

Anqing City, poor child health is a significant issue. Compared to other large cities in China, a lack of hygiene and health education has made the Anqing children's health situation lower than the national average. Moreover, Anqing City is an area with the rare epidemic of schistosomiasis (colloquially known as Snail fever or Bilharzia).

4.5 Family Structure

From 1979 until 1 Jan 2016, China had a strict family planning policy, commonly referred to as the One-Child Policy. The result of this on the family structure is that now there are commonly two generations of the population who only have one successor to continue their family lineage. It is historically and culturally typical and essential for the older generation to move in with their child or grandchild as they reach retirement age. Not only is there significance in the emotional connection of the child carrying on the family name and lineage, but there is also economic significance, as the working child is expected to support their retired family members.

China is officially an atheist country, but it has a long history of cultural spirituality. The teachings of Confucius are not as actively practised as they once were, although the ideas and principles are a substantial part of Chinese society and cultural identity, particularly amongst the older generations. This cultural spirituality is seen in the form of Feng Shui. For over three thousand years, Feng Shui has developed a design theory that involves ecology, natural phenomena, biophilia, conservation, spatial design, and architecture. There are four fundamental philosophies in Feng Shui: Ying Yang (complementary and balance), Bagua (Eight Diagrams), Wuxing (five elements), Chi (flow of energy). Feng Shui is traditional Chinese geomancy (a way of interpreting divine patterns). The core of Feng Shui is to achieve harmony between humans and nature, and the spiritual engagement and integration of the environment. If Feng Shui rules are applied to people's life objects, it believed that would improve their wealth, health, luck, fame, relationships, and knowledge.

One such example is the idea that buildings should face south (China is in the northern hemisphere, so it is equivalent to buildings facing north in New Zealand). We now know that facing buildings south is beneficial for a range of health conditions, as well as physical comfort. The increase in light and heat helps to keep buildings warmer and drier, reducing the negative health impacts commonly seen when living in damp environments. The practice of positioning living spaces towards the sun is now a fundamental part of good architectural design, and there is a wide range of research backing this up. Historically in China, this is was linked to the benefits of Feng Shui. In this project, two of the four fundamental philosophies will be explored and used. They are Ying Yang and Bagua. Wuxing and Qi are out of scope for this project.

4.6 Ying Yang (Complementary and Balance)

Ying and Yang are the two opposing principles in nature; the former feminine and negative and the latter masculine and positive. The symbol of Ying Yang is a circle that is separated by a curved line to black and white or solid and void; black represents Ying and white represents Yang. The black part has a white dot in it, and there is a black dot in the white part. Therefore indicating that Ying has Yang inside of it, and Yang also has Ying inside of it. The two elements are a unity of opposites and interconversion; they complement and balance out each other. In ancient China, people used Ying Yang to explain and describe objects because things were created in pairs. Ying Yang creates the balance and harmony of the natural environment and atmosphere.

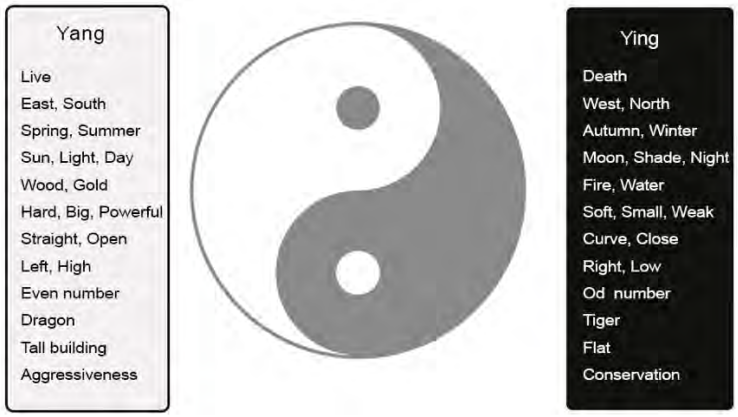

Figure 2. Ying and Yang elements, as pertaining to health care

4.7 Bagua (Eight Diagrams)

Bagua is a system linked to the change of objects within the environment. The two symbols of Ying Yang are combined to create eight diagrams which explain natural phenomena. The eight diagrams are (Qian) Sky, (Kun) Earth, (Xu) Wind, (Zhen) Thunder, (Kan) Water, (Li) Fire, (Gen) Mountain, (Dui) Lake. Each of the diagrams has its direction, colour, number, and element, which can be matched and combined to become 64 terms that symbolize everything in the world. Bagua claims that if directions, materials, colours, and shapes are used correctly, this will improve a person's wealth, health, reputation, relationships, family, fertility, skills, and career.

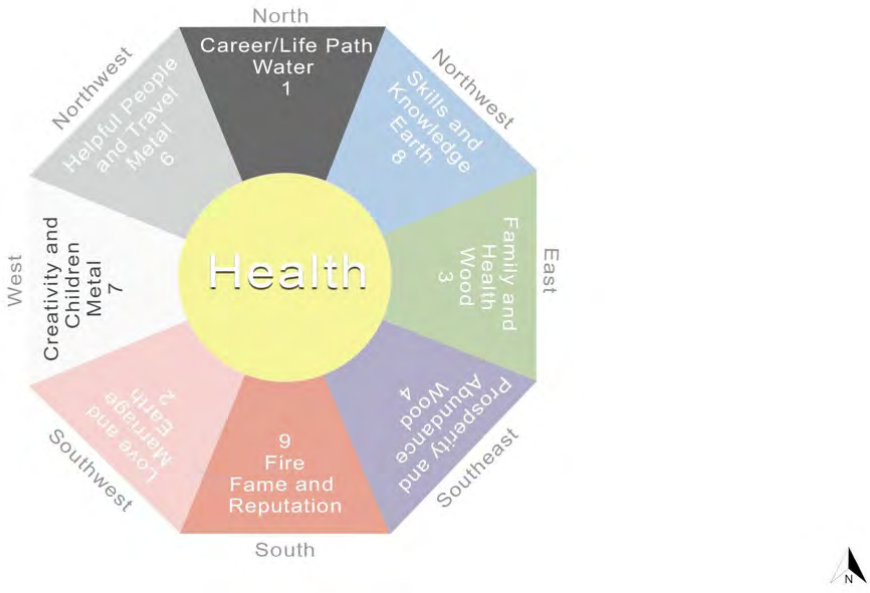

Figure 3. Bagua elements

5 Addressing the Site Through Bagua

Having facilities that allow people to connect with their spirituality has been shown to improve levels of hope, combined with the vital cultural importance of Feng Shui, has led to the principles of Bagua being used to address the overall site layout as Bagua is the ancient

Chinese methodology used to locate different spaces. Health is in the centre of Bagua, which dictates that the main Outpatient Department and Medical Surgery Technology Department are located in the centre of the site; therefore, Yellow is used as it is the representative colour of health. Red is the representative colour of fame and reputation and is therefore perfect for the south side main entry. The wards will be located on the north side, which represents life paths. Black is the representative colour of the life path. There will be one main entrance on the south side of the site, which will go directly to the Outpatient Department. If the patient's illness requires further treatment, they will be directed to the Medical Surgery Technology Department; therefore, the connection is needed between these two departments. On another side, the Emergency Department will have its own entrance, and it will also require quick access to the Medical Surgery Technology Department. A link between the wards and the Medical Surgery Technology Department is essential also. Consideration has been given to the young patients in the wards, who have different requirements to those in the Outpatient Department. They need safe, fun, relaxing environments and the parents need relaxing spaces too. On the Northside, there is an entry for visitors for the wards, and close by is a motel for long-term visitors and families. A dining hall will be open to the public. The colours used in the different departments are related to Bagua.

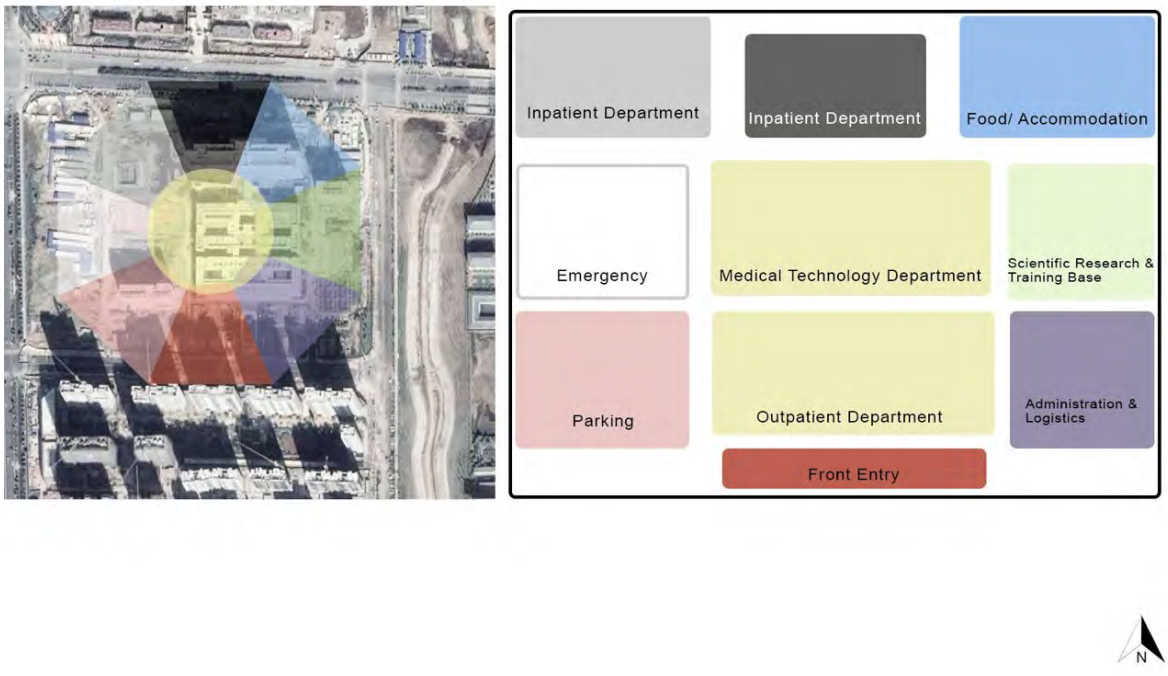

Figure 4. Bagua and Site: Daqiao Economic Development Zone, Anqing City

6 Exterior of Building

Addressing the buildings through achieving the Balance of Ying Yang: while new-born babies and children are healed in a hospital, which can be considered Yang, overall most patients who stay are sick, which is why hospitals are generally considered Ying environments. The architecture of the hospital should, therefore, have a more significant number of Yang attributes to create balance within the environment. A few of the elements that can bring Yang energy to the building include stone, concrete, steel, and wood. Natural sunlight is directly from the sun, and "sun" is pronounced "yang" in Chinese. This is the key

of Yang energy buildings. Even numbers, along with sharp edges and clean-cut design are considered aggressive in Feng Shui, and will also bring Yang energy to the building. Stone carving on the building, or sculpture, is a way to represent long life, happiness, luck, health, and Yang.

7 Metaphors and Fables

Ancient Chinese people used the imagery and metaphors of stories/fables in their buildings, through carving. In traditional Chinese storytelling and mythology, the connection between elements and beings who share similar traditional characteristic and pronunciations is essential. For example, the pronunciation of the word for a bat in Chinese is the same as the pronunciation for the word for fortune and happiness. Therefore, the bat has become a symbol for these attributes.

This kind of connection is significant and vital in traditional Chinese storytelling and wordplay and continues to be relevant today. In Chinese, Sheep is pronounced “Yang” which shares the same pronunciation as the word sun. Therefore, sheep and sun-related patterns are considered Yang energy. An auspicious phrase “san yang kai tai” literally translates to “three sheep open the harmony world”. The content of this image is three sheep looking up at the sun. It symbolises the beginning of spring when all the flowers bloom, farmers start planting rice, the cold winter is gone, and there is a fresh start to the year. A bat and peach combination indicates good fortune and long life. Bat (Fu) shares the same pronunciation as happiness (Fu). In an old Chinese story, the peach was the Queen Mother of the West’s (goddess in Chinese religion and mythology) fruit, which was planted in heaven. It can bring anyone who eats it an additional extra six hundred years of life. In this research project, the design will use the concept and pattern of “san yang kai tai” (three sheep looking up to the sun) for the three central departments; Outpatients, Medical Surgery Technology and Ward. Yang elements will be included externally in the building design. Additionally, bat, deer, sheep and peach patterns will be used for the building’s interior design, for different functional spaces.

8 Registration Area

The registration process in Chinese hospitals has traditionally been a significant concern and bottleneck in the system. The process is slow, painful and frustrating, and creates a range of feelings, including hopelessness, for patients. Powerlessness: The lack of control over the situation leaves patients feeling powerless and at the mercy of the system. Limitedness and helplessness: Due to the physical or mental limitations of some patients, they may find it difficult or entirely unachievable to communicate their condition with those at the registration desk. Similarly, the process of standing in a queue of people for extended periods is something that may be difficult or unachievable for some patients. Captivity: Even for the non-disabled person, being forced to stand in large crowds of people for extended periods is an unpleasant experience. The current system is not patient-focused; it is system-centred. There are no options or scales, nor any degree of flexibility designed into the system. It is a “one size fits all” approach.

8.1 Solutions: There are three different styles of registration hall:

8.1.1 Street style

A street-style hall provides essential services and commercial areas along the sides of the hall. It provides ample spaces for visitors and multiple visual connections. It brings the community into the hospital setting, reducing the hospital-like feeling. For a children's hospital, it can provide a distraction for children and relax them. The street style registration hall makes it easy for patients and families to follow directions.

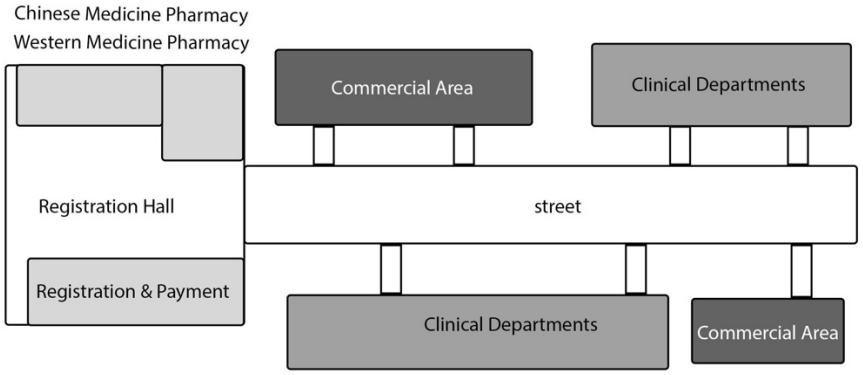

Figure 5 Street style

8.1.2 Courtyard style

A courtyard style registration hall has all the essential services in one lobby area and all the different clinical departments around the four sides. It is clear to see where the department is that the patient needs to go to, but this layout does not create any sense of entry space, and it is easy for the central area of the hall to become overcrowded.

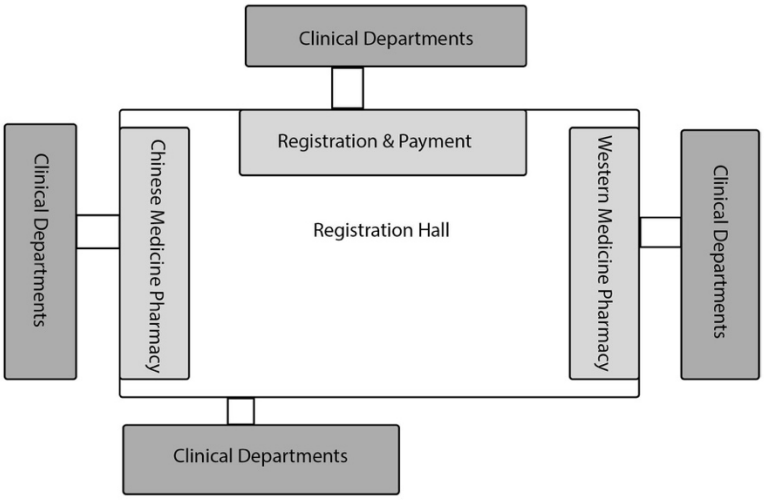

Figure 6. Courtyard style

8.1.3 Wings style

A wings-style registration hall has different clinical departments on the left and right sides of the main hall area. This provides an excellent visual reference for visitors when they enter

the hall, but if the visitor goes to the wrong place, it requires a great deal of walking for them to get to the correct area.

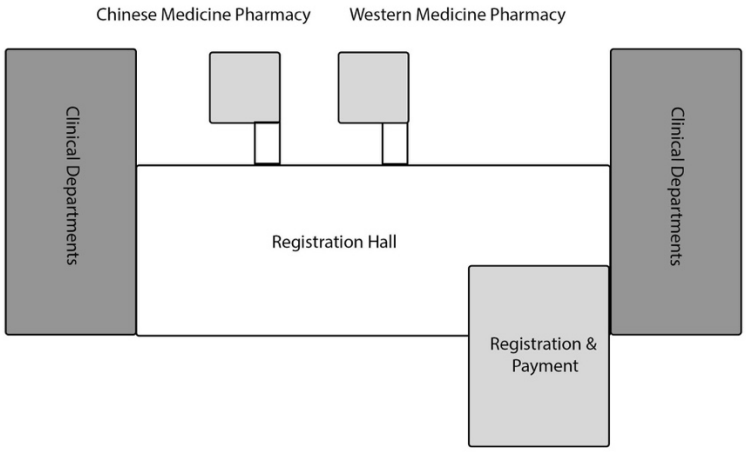

Figure 7. Wings style

9 Clearly defined and separated areas for repeat/regular check-ups

In China, people have to visit the hospital for things that in New Zealand would be part of a regular check-up. Including regular check-ups such as blood pressure readings and receiving IV drips. The fact that these areas are not separated also adds to the congestion seen in the registration process. Improvements to this system could be seen by taking inspiration from the New Zealand model of decentralised healthcare. This project would propose to separate the irregular and regular facilities within the outpatient department building and give each their own area and reception. Not only will this reduce the number of patients visiting the main registration area, but it will also allow both registration areas to better cater to the needs of those who are visiting them. The design will locate the main IV drips (infusion) room and injection room near the main entry for repeat patients.

9.1 Key Issues: Unpleasant waiting areas

Patients and their family spend much time waiting for treatment, and the waiting areas are usually rather unpleasant. They generally consist of little more than a few rows of uncomfortable metal chairs in a room with sterile white walls; often they are not even separate areas, and the chairs just run along the sides of a hallway. These unpleasant waiting areas are dull, uninspiring, and provide little in the way for the different ages and abilities of people, nor do they make any accommodation for families to socialise. Children scale furniture are not provided for, and there are no spaces for the children who visit the hospital to play or have any fun while they wait. These waiting spaces are depressing and deeply unpleasant to spend time in; they make the patients, and their families feel unhappy and hopelessness.

9.2 Key Issues: Hospital Happiness

Typical Chinese hospitals at the best of time are dull and uninspired. The sterile environment and highly functional architecture do little to inspire hope or joy. We know that hope, and the effect and connection it has with mood have significant effects overall wellbeing and health outcomes. However, the current hospital designs do little to improve the mood of those who visit them, and usually, the opposite is true with hospitals leaving people in a worse mood

than when they entered. This negative shift in mood and hope likely have significant adverse effects on the patients' effects overall wellbeing and health outcomes

9.2.1 Solution

The building will aim to make the visit of patients and their families as enjoyable as possible. The design will include a range of colours, textures, art, and sculpture that will capture the imagination as well as a range of spaces and design elements that will aim to create a feeling of wonder and joy. The architecture of the building through its design will aim to make sure that everyone who visits leaves happier and more hopeful than when they arrived.

The Outpatient Department will aim to provide:

- Courtyards that have a visual connection for infusion patients and medical staff.
- Street-style registration hall to keep people flowing, bring the community in, minimise the look of the hospital-like environment.
- Separate visitor and medical staff entrances, to give them their own spaces and ease of access.
- Children's play spaces on each floor to provide distraction and relaxation for different age groups of sick children.
- Façade that helps to utilise direct sunlight connects with Feng Shui elements and provides for a relationship with the natural surroundings.
- Soft material to reduce the harshness and cold feeling of the hospital.
- Different colours and theme to category different area and clear wayfinding

Figure 8. Southeast View – Main Entrance

Figure 9. Internal walk way and shops

10 Summary and critical appraisal of research

The culminating design is an example of how the spaces and design elements of a hospital, alongside the decentralisation of a centralised healthcare system, can work to provide patient-centred care that ultimately makes hospitals more hope-filled environments.

Models of successful patient-centred hospitals and joy-filled children's facilities were explored, as was research into Chinese cultural and medical history to understand better the roles these could play in making improvements and finding solutions to problems found in the Chinese healthcare system. The project aims to create a hospital that better fits the needs of its patients through having design elements and spaces that can cater to a range of ages and abilities as well as making these spaces flexible enough to be used by all in a comfortable way. As research on this project progressed, it became apparent how significant but underutilised the power of hope is to medical outcomes. The project uses strategies for creating hope, such as strengthening interpersonal relationships, exploring faith and gaining control, and then applies these to the design.

Figure 10. Left: Northwest View – rear, Right Atrium and Lobby

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New Ecosystem Business Designs for Regional Revitalization

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As populations and economic activities end to be concentrated in Tokyo and other metropolitan areas in Japan, regional areas are in decline. Even though public subsidies and incentives have been provided in these areas, they have not always had the desired effects as efforts to improve added value through redesigning local economies have been limited to local businesses. This paper examined service-business ecosystem designs and compared regional economic activities with metropolitan areas to clarify what was needed to activate regional economic activities and link them with the global economy and metropolitan areas.

Keywords: Regional activation; Business Ecosystem Design; Global and Local Economy

1 Introduction

In many developed countries, rural population is declining and aging, rural economies are shrinking, meaning there are now significant differences between rural and metropolitan areas. In metropolitan areas, the economic level tends to be high, while the quality of life is not always good and as rural areas tend to be more conservative, the environment tends to be poor for new business developments to improve regional value, these have tended to be individual successes that have not had any significant impact on rural ecosystems. Generally, the rural business ecosystem has been focused on local production for local consumption, and there has been little research on ways to connect local and global markets.

This study compared the local and global economies in Japan in the Kyusyu and Tokyo areas using a document survey and interviews to extract the current regional activation problems and determine solutions based on service logic and design.

2 Current Reality in Rural Areas

2.1 Lifestyle

Rural life has rich nature, nutritious food, inexpensive housing, and a comfortable lifestyle; however, there are less employment and business opportunities. Rural life in Japan was examined using an ethnographic survey of web blogs and a document survey of web portals and associated statistics. Agricultural community and mountain areas were removed from

the survey because the population was low in these areas, and the community differences were so large that it was difficult to generalize the results.

The drawbacks of rural life

- fewer job options,
- fewer entertainment options,
- inconvenient transportation development,
- bothersome social activities, and
- many insects.

The drawbacks of urban life arewere identified as follows.:

- expensive rents,
- crowded trains,
- poor environment for raising children,
- little nature,
- poor-quality meals, and
- cold society.

Open information in blogs by people who had moved to rural areas and urban and rural area web portals was examined. It was found that the job options in rural areas were poor, especially for knowledge-intensive workers because there were few rural companies ; however, there were more than double the number of hospitals , i.e., 13 per 100,000 people in Kagoshima, compared to only 4.4 per 100,000 people in Tokyo; this indicated that there were possible job openings in the medical and welfare areas.

There were fewer options in the rural areas, and the job listings were different from those in the urban areas.

The following comments were made about the rural entertainment options “There are no third -wave spots for consumption, and there is less cultural diversity than in Tokyo” and “There were less drinking sessions after I moved to Kagoshima ”The live sports ratio was also low with only 17.6% being involved in Kagoshima , which was ranked 36, compared to 23.8% in Tokyo , which was ranked 6, and there were also fewer industrial entertainment options. However, comments such as “There are rich mountains, oceans and rivers if I drive 30 minutes” indicated that there were greater outdoor opportunities in rural areas compared to urban areas.

Public transportation in rural areas is not well developed because of the low population density, with rural people noting that a train or bus every hour was a norm in local cities. Therefore, most rural people need to rely on their own means of transportation. Public transport, however, is very crowded in metropolitan areas compared to rural areas.

However, cooperative human relations are strong in rural areas because of the sparse population, with some people commenting that “cooperating with each other at events helps us get to know each other”.

Data on the volunteer action ratio found a greater local event involvement in rural areas, with 32.6% being involved in Kagoshima, which was ranked 5th, but only 21.6% being involved in Tokyo, which was ranked 46th. Local people in Kagoshima commented that “work ends at 18:00, and I can go back home at 18:30 every day, which means that I have much free time until go to sleep”, and “there is 20 minutes more free time in Kagoshima than in Tokyo,” which means that there are stronger relationships developed in recreational activities.

People think that rent is expensive in the metropolitan areas however, the statistics indicated that rent in Tokyo was quite expensive, but that there was no difference between the rent in the Kyusyu area and commutable Tokyo areas such as Ibaraki, Tochigi, and Gunma. Therefore, rent in Tokyo was seen as extraordinarily expensive, whereas rent in rural areas was seen as affordable.

There were many comments that the living environment for raising children was better in the rural areas because it has many natural areas and good facilities. For example, the cost of maternity is only 439,818 yen in Kagoshima compared to 609,189 yen in Tokyo, and Kagoshima has 146 athletic parks per million people compared to only 9.5 in Tokyo.

Although eating preferences are typically based on personal judgment some comments suggested that local food was more affordable and delicious in rural areas; for example, one commenter said that “rice and vegetables are much more delicious. If you look for local foods, there are plenty of fine cafes and restaurants. I feel sorry that people in urban area have to be satisfied with only chain restaurants.” However, communication with others in rural areas can sometimes be difficult; for example, one commenter said that “the people are cold to outsiders; the dialects are difficult; and the local rules are not easy to understand. Sometimes, rural people have local customs specific values, and mannerisms that are different from global standards.

Therefore, the differences between rural and urban lifestyles can be summarized as follows. Although there are wider job options, better entertainment, and more convenient transport in urban areas, the living costs are high in core capital regions, and the number of community facilities and hospitals is low. Food is more affordable and nutritious; there is a wider range of various community facilities; and there is more free time to volunteer and spend with family members in rural areas, but there are limited job options, and the local rules are difficult to understand for outside people. Thus, although daily life is easy, there is little change in rural areas, and people cannot easily deal with change.

Therefore, although there is a greater than expected fullness of life in rural areas, the areas are economically and socially flat, and there is a lack of willingness by people to change the conservative lifestyles.

2.2 Local Business Activities

Toyama explained that there were two main economic regions: global and local (Table 1.). He pointed out that face-to-face labor-intensive services were the main business activities in rural economic regions, as opposed to the knowledge-intensive service industries in urban city regions. To understand the structure of the rural economy and to determine business

areas that could be suitable for new service- business ecosystems, materials from both Tokyo and Kagoshima were consulted.

Table 1 Global Economy and Local Economy

	Global World（Global economic zone）	Local World（Local economic zone）
Products	Goods and portable information portable	Experience and service (basically face-to-face) consumed on the spot at the same time as production
Industrial Structure	Manufacturing industries, mainly large companies Complete competition in the global economic zone labor productivity is in the world's top class	Service industries: mainly middle and small businesses Incomplete competition in the local economic zone Very low labor productivity
Employment	Knowledge intensive (Highly skilled human resources centered on high wages)	Labor intensive (Mainly average human resources, with low wages)

The economic growth ratio in Tokyo has been measured at a 2.0% nominal rate and a 1.8% real rate. At the point of production, both the nominal and real wholesale and retail industry rates increased. At the point of distribution, increases were mainly experienced in property income and business income, with the income of Tokyo residents increasing by 2.8%. In outgoings, both nominal and real rate gross capital formation ratios increased in Tokyo. From an analysis of the company-based added value in Tokyo by industry, because global company head offices are concentrated in Tokyo, the ratio of manufacturers, wholesale distributors, retailers and service companies such as financial, insurance, and information-communication companies is large. In terms of the circulation in the local economy, the ratio of income flowing outside was high, indicating that there were many workers in Tokyo coming from outlying cities. However, the ratio of income flowing in was also very high, indicating the large investment flow from other areas.

The economic growth ratio in Kagoshima was a 3.2% nominal rate and a 1.3% real rate, with the nominal rate having consecutive positive growth for 3 years and the real rate having positive growth for 2 years. At the point of production, manufacturing, utilities, waste treatment, and the wholesale and retail industries increased, but the construction industry decreased. At the point of distribution, business income increased. In terms of outgoings, private final consumption expenditure and government final consumption expenditure increased. Compared with other areas, agriculture, forestry, and fisheries contributed 3.7%, and the rural area had the largest number of veterinary business offices in Japan. From an analysis of the company-based added value in Kagoshima by industry, the ratio for medical welfare was the highest, the ratio for wholesale distributors was second at about the same as that in Tokyo, and the ratio of construction, lodging, and restaurant businesses was high. Compared to Tokyo, in terms of circulation in the local economy, the distribution of income from outside was relatively high because of subsidization; however, more than half the private investment flowed to the outside. The income distribution from the outside flowed out, and there was low investment in the local area. Compared to the economic activities in Kagoshima, Tokyo had significant economic alliances with surrounding prefectures and had many global economic enterprise head offices. There were also many knowledge-intensive service companies such as information and telecommunications companies and performance production activities, and there was significant financial investment coming in

from outside Tokyo. In Kagoshima, by contrast, the main economic activities were labor-intensive ones such as medical welfare, lodging, and restaurant businesses. The business ecosystem in the private sector appeared to be closed in the local community as subvention and dividends were not used in the local community. As Toyama pointed out, the rural economy was based mainly on labor-intensive service businesses connected geographically and tightly to the local economy. The local ecosystem was optimized to local business sizes and economic expansion, and change ecosystem investments tended to go outside.

Therefore, overall, no new resources or ecosystems had been developed to enhance local economic activities.

2.3 Actions for Expanding Local Activities Listings

Many local governments have been planning to increase the earning power of the local community. However, Hada and Watanabe claimed that these actions were insufficient from a marketing viewpoint and commented that the process needed consecutive marketing actions to excavate regional resources, develop local brands, and restructure the local community. Based on an idea associated with the consumption of things in the modern age, issues from two action materials in Kagoshima were extracted for service marketing.

2.3.1 Kagoshima's Vision for Future Creation

Kagoshima Vision for Future Creation was adopted as a local government plan, as follows:

"As the basis for the whole prefectural administration, from a mid- to long -term perspective over the next 10 years, the Kagoshima Vision for Future Creation was announced on March 2019, with a focus on clarifying the goals and basic policies in Kagoshima, sharing these with the local residents, and developing the next Kagoshima under an 'All Kagoshima' spirit to carry it on to the next generation. "

This plan was focused on the development of local resources for sightseeing and promoting the rich agricultural, forestry, and fishery products, with the future plans targeting local residents. However, this plan was a vision only, and it did not include any concrete action plans or details about how to increase the region's earning power.

2.3.2 Satsuma Village Future Tourism Design

The sightseeing future laboratory workshop identified seven issues: lack of connection between the sightseeing business operators, lack of purpose in the events, inability to create events in which young people could participate, unacceptable feeling that foreign nationals were the target, lack of crisis awareness in Satsuma village, aging existing facilities, and lack of connection to local history or nature. Then, the sightseeing resources at Satsuma village and the ideal future for Satsuma village were considered with five teams developing activities for test marketing. Although the plans were in the starting phase and had a concrete direction there was no Segmentation, Targeting and Positioning (STP) for marketing 2.0. Members who had participated in the planning were interviewed and claimed that concrete action plans such as marketing and resource value analyses were the next actions.

Therefore, the research found that even though the local government had assigned participants to the local action policies in the planning phase there were no clear promoters or a system in action phase. Furthermore, although there were adequate staff, budget, and

concrete plans such as an STP for the conduct of local branding and marketing, there was no framework for the PDCA cycle. Therefore, the business model was developed based on the general GDL, and the main resources based on physical operations but not on any operations for service value creation.

3 Design for Local Service- Business Ecosystem Creation

3.1 For Regional Activation

The current community activation and action plans from the local government initiatives were extracted from the abovementioned research as follows:

- The rural ecosystem is currently running well and does not need to change until it fails.
- The rural ecosystem is optimized toward labor-intensive service businesses, and there is no investment needed to adopt a new business model and expand the economy.
- The community activation plan included resource detection for GDL, but there have not yet been any concrete action plans developed as to what values need to be created.
- Although the need for community activation is necessary at the macro level, it is believed that there are no problems at the local micro level. Therefore, maintenance of the local economy, and development of a hybrid model to connect with the global model are considered most suitable for activating the local community.

3.2 Connection between the Global Economy and the Local Economy

In modern society, mobilizing basic resources such as people, goods, and money and information has become easier.

Location limitations can also be overcome because of the mobile work and office sharing opportunities. Logistics has also changed because of the increase in door-to-door and unmanned drone delivery services; payment systems are much easier because of online banking, virtual currency and FinTech developments; and it is easier to gain real information using new recent computing interface technologies and AI. With this situation in mind, a frame of connection between the monetary knowledge-intensive global economy and labor-intensive local economy has developed, as illustrated in Fig.1.

The economic goal is associated with the need for population growth residential populations moving in, interactive temporary stay populations, and relational economically or informationally connected populations. The clear service operations were mapped on the frame to establish possible service businesses.

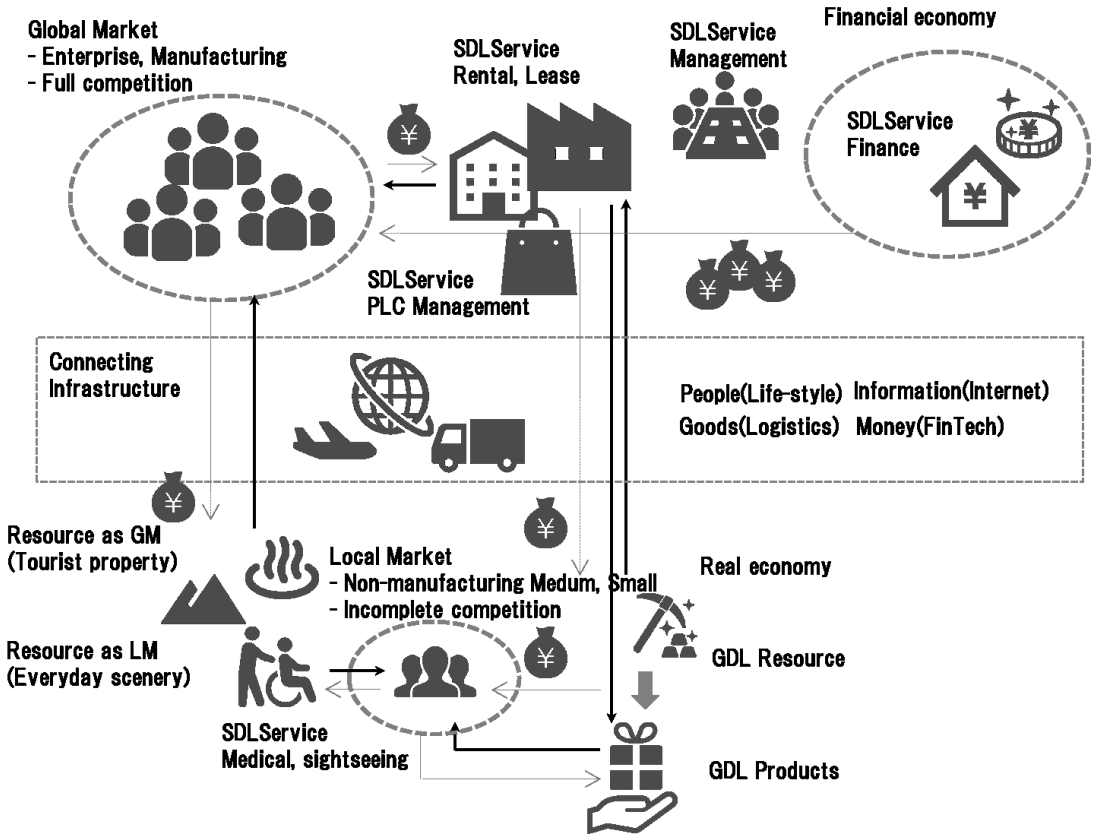

Figure 1. Connection Model between the Global Economy and the Local Economy

4 Future Research

In this paper, we considered an overall service design framework for regional activation rather than only for individual local business development. To connect the global and local economies and to establish new service businesses concrete resource finding, and marketing activities are needed. In our following research we plan to develop a concrete case study that encompasses actual action learning practices in Kagoshima, in the southern part of Japan.

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Perceived Wellbeing Effects of Designer Fractal Patterns: Visual Complexity and Interior Spaces

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This paper introduces my work-in-progress research into the perceived wellbeing effect – in particular through visual preference, visual interest and mood response – to fractal patterns in the built interior environment. The novelty of this research lies in the type of fractal patterns used as stimulus, which are inspired by a historical retrospective of wallpaper and upholstery fabric patterns. This work-in-progress aims to produce surface decorations that conform to a prevailing current aesthetic, but also bring into our spaces an ordered visual complexity, improving our psychological wellbeing and mood while maintaining our link with nature through practical biophilic design practices. This research aims to answer two questions: To what extent do the proven perceived wellbeing effects of statistical/natural fractals hold true for designer fractal patterns? In what ways are forced choice protocols beneficial when assessing perceived effects of the design of interiors, and what are the consequences of not utilizing methodologies that value ecological validity?

Keywords: fractal, interior design, biophilia, wellbeing

1 Introduction

Although humans spend the majority of their time indoors, within built spaces, these interior spaces often suffer from banal blank forms and dull rigid lines. Our spaces address ADA regulations in terms of dimensions and ergonomics which but do not always address visual interest, visual preference, and mood as conditions of wellbeing. A curative approach may be found in opposing 'careless' design by making wellbeing a paramount factor, instead of becoming entrenched in ideological debates and novelty and forgetting the human element (Sagmeister & Walsh, 2018). Nowhere is this concept of wellbeing more important than within interior space, and that is why prioritizing it in interior spaces has been the aim of interior designers who understand the profound effect of the built environment on our psychological, physiological, and emotional wellbeing. A deeper awareness of the practical application of biophilic design practices among interior designers can lead to more stimulating spaces that enrich our wellbeing.

2 Biophilia's Emotional, Physiological and Psychological Effects

Human affinity for nature, termed biophilia, has captivated designers interested in designing for wellbeing. The aim of these designers is to leverage the restorative effects of nature into interior spaces. The favourable impact can be categorized into psychological effect,

physiological effect, and an aesthetic effect. Psychological effect can be understood as an increase in "… emotional restoration, with lower instances of tension, anxiety, anger, fatigue, confusion and total mood disturbance…" (Browning, Ryan, & Clancy, 2014, p.11). Positive physiological effects that occur when in the presence of nature include "…relaxation of muscles, as well as lowering of diastolic blood pressure and stress hormone levels in the bloodstream." (Browning et al., 2014, p.11) The aesthetic effect of nature has been linked to an evolutionary system of processing natural elements. This system is titled Natural Information System (NIS). A positive aesthetic experience creates a positive emotional response that motivates us to inhabit a natural scene that is deemed hospitable (Joye, 2006).

The 14 patterns of biophilia (Browning et al., 2014) are an attempt to create an encompassing framework for all biophilic design. The theory of biophilia suggests that humans have always favoured nature in their environmental experiences. From physical plants and running water to natural analogues, such as feelings of refuge and serenity, nature has found its way into our built spaces. A clear benefit lies in expounding on a particular pattern's practical application and real-world parallelisms for design education and practice.

My interest lies in expounding on a particular "biophilic condition" (Browning et al., 2014, p. 62), specifically the Nature Analogues category with a focus on order and complexity, which offers an opportunity for further study. Nature Analogues is an interesting focal point, because its focus on biophilic conditions created through "indirect evocations of nature" (Browning et al., 2014, p. 10). The condition of 'Complexity and Order', which is the focus of my investigation, has been described as having "Rich sensory information that adheres to a spatial hierarchy similar to those encountered in nature." (Browning et al., 2014, p. 10). This condition of order and complexity is exemplified in fractal patterns seen in nature and architecture and provides a foundation for insights into biophilia's emotional, physiological and psychological effects.

3 Fractals

Fractals were first categorized by Benoit Mandelbrot in his 1982 book "The Fractal Geometry of Nature." To judge any geometric pattern as a fractal, it must demonstrate certain characteristics. The pattern must repeat, and its repetition must happen at different scales. Elements of the pattern must also be self-similar. It must also be infinite in its repetition (Parashar & Bandyopadhyay, 2014). The characteristics of fractals have been set out by the famed mathematician, Kenneth Falconer, to include (Falconer, 2003)

1. Fine structure, a cascade of detail
2. Irregular, hard to describe with Euclidian geometry
3. Self-similar, exact or statistical (mathematical or natural)
4. Can be described in a very simple way, recursion, translation, etc.

However, Falconer warns us against taking this list of characteristics as a hard and fast rule to decide what is 'fractal' and what is 'non-fractal'. In fact, he compares the definition of 'fractal' to the definition of 'life' in biology. He says:

> *"The definition of a 'fractal' should be regarded in the same way as a biologist regards the definition of 'life'. There is no hard and fast definition, but just a list of properties…it seems best to regard a fractal as a set that*

has properties … rather than to look for a precise definition which will almost certainly exclude some interesting cases." (Falconer, 2003, p. xxv)

The natural world is filled with fractal patterns of different types and levels of complexity, these patterns are referred to as natural or statistical fractal patterns. Their abundance in nature gives humans have a strong evolutionary reason for processing them, resulting in an ease that is enjoyable and a ubiquity that is familiar (Joye, 2006).

Examples of mathematical (exact fractals) and natural (statistical fractals) can be seen in the images below.

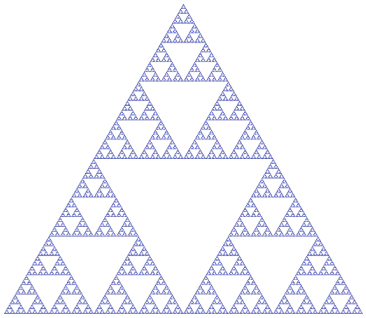

Figure 1. Sierpinski's Triangle, an example of an exact mathematical fractal (Beojan Stanislaus, Wiki Commons) https://en.wikipedia.org/wiki/Sierpinski_triangle#/media/File:Sierpinski_triangle.svg

Figure 2. Romanesco broccoli, an example of a statistical natural fractal (AVM, Wiki Commons) https://en.wikipedia.org/wiki/Cauliflower#/media/File:Cauliflower_Fractal_AVM.JPG

Joye comments on the abundance of fractal patterns in nature and their relationship to wellbeing in the following:

"While the fractality of nature has been amply demonstrated, there is now reason to believe that the presence of fractal geometry (in a sense) underlies these biophilic responses. To put it very crudely, it is not the tree that causes these emotional responses, but the fractal mathematics of the tree." (Joye, 2007, p.318)

3.1 Wellbeing and Fractals

Biophilic design strategies, including the application of fractal patterns, promise a wellbeing effect on the inhabitants of space (Browning et al., 2014). More specifically, studies show a strong relationship between statistical (mathematical) fractals and wellbeing. The self-reported perceived wellbeing effects of fractal patterns have been documented as an

increase in visual interest, visual preference, and mood (Abboushi, Elzeyadi, Taylor, & Sereno, 2019; Forsythe, Nadal, Sheehy, Cela-Conde, & Sawey, 2011). Other studies in laboratory settings have proven wellbeing effects in physiological effects of reduced heart rate and diastolic blood pressure, as well as a decrease in alpha brains of the brain (Abboushi et al, 2019; Bies, Blanc-goldhammer, Boydston, Taylor, & Sereno, 2016; Browning et al., 2014; Forsythe, Nadal, Sheehy, Cela-Conde, & Sawey, 2011; Hagerhall et al., 2008; Joye, 2007, 2011; R. P. Taylor, 2006; Williams & Aeon, 2017). In addition, evidence has shown that the fractal-wellbeing relationship is strongest with fractals of mid-range complexity, categorized by a fractal dimension of 1.3 -1.5 (Abboushi et al., 2019; Hagerhall et al., 2008; R. P. Taylor, 2006; Richard P. Taylor & Wise, 2002).

3.2 Fractal Complexity and Wellbeing

The level of complexity of fractals is measured through fractal dimension (D), which can range from 1.1 -1.9. It is explained best in the following quote: "Fractals are typically characterized by a variable called the fractal dimension (D). This parameter quantifies the fractal scaling relationship between patterns at different magnifications. Based on the D value, fractals can be categorized into low (D=1.1-1.3), medium (D=1.3-1.5), and high complexity (D=1.5-1.9)." (Abboushi & Elzeyadi, 2018, p. 2). A visual manifestation of these patterns in exact (mathematical)) fractal patterns, statistical (natural) fractal patterns, and hand-drawn patterns can be seen in Figure 3.

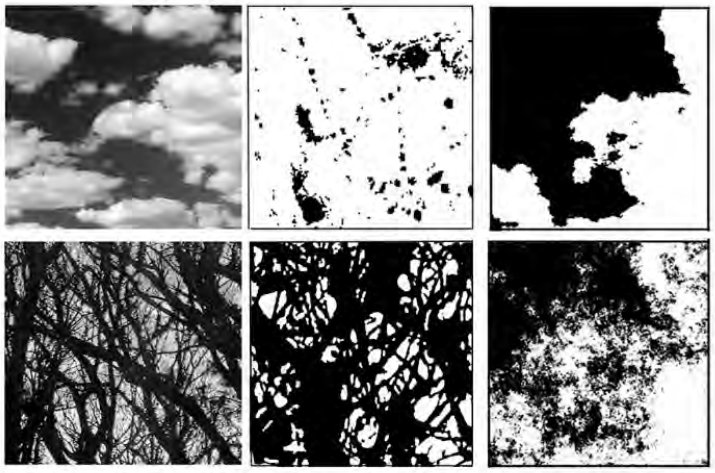

Figure 3. "Fractal complexity in nature, art and mathematics. The left column shows clouds with D = 1.3 (top) and a forest with D = 1.9 (bottom). The middle column shows Jackson Pollock's Untitled 1945 with D = 1.1 (top) and Untitled 1950 with D = 1.89 (bottom)" Taylor et al., n.d., p. 7). *The right column shows variance of D in a computer generated pattern, with a higher D in the bottom right pattern and a lower D in the top right pattern.*

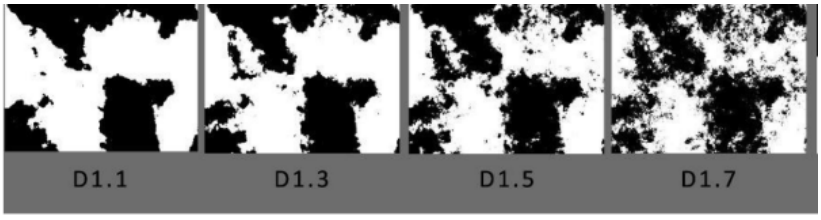

Figure 4. After (Abboushi et al., 2019, p. 60)

This preference for mid-range fractals is codified in Dr. Richard Taylor's model of Fractal Fluency. A possible reason put forth by Taylor is that the human visual system is the most

comfortable with mid-range fractals because they are the most prevalent in nature. He states: “Because many of nature’s fractals exhibit mid-range complexity, we proposed a ‘fractal fluency’ model for the human visual system in which it has adapted to efficiently process these mid-complexity patterns. The model [of fractal fluency] predicts that this ‘effortless looking’ will result in the enhanced performance of visual tasks [as an element of wellbeing]…” (Taylor et al., n.d.)

4 Fractals in Design

These findings, concerning midrange fractals and wellbeing, have clear implications for interior design specifically, and design generally. In fact, manifestations of fractal patterns are seen in the urban scale (macro), the architectural scale (middle), and the decorative interior scale (micro) (Kiani & Amiriparyan, 2016).

Some examples of these manifestations can be seen in the urban design of the African Ba-Ila villages (Eglash, n.d.) (See Fig 5).

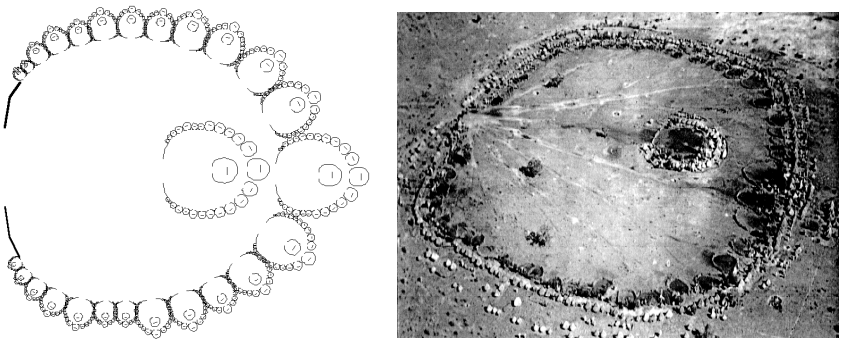

Figure 5. The above images show the fractal structure of the Ba-Ila villages (Eglash,nd)
https://homepages.rpi.edu/~eglash/eglash.dir/afractal/afarch.htm

Fractal repetition and scaling is common in Hindu temple design, and is a clear example of fractals in architecture (see Fig 6) (Salingaros, 2014).

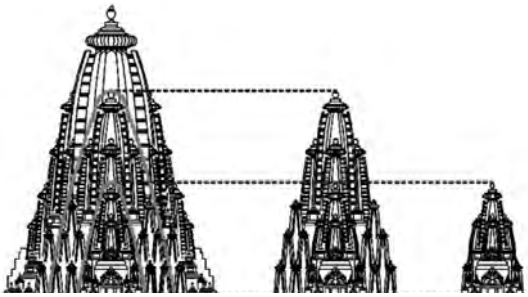

Figure 6. The fractal quality of self-similarity is clear in the forms of Indian temples. (after Iasef Md Rian) (Joye, 2011)

At the microscale, fractal qualities can be seen in Islamic patterns, both 3D *muqarnas* and 2D tiling (Kaplan, 2011; Kiani & Amiriparyan, 2016).

Figure 7. (Left) Safavid era patterning on the interior of a dome, showing self-similar, fractal qualities (Kaplan, 2011).

(Right) The muqaranas of the Aleppo Citadel, Syria. Its structure with self-similar, nested fractal qualities. https://en.wikipedia.org/wiki/Muqarnas#/media/File:Aleppo_Citadel,_Syria_(5077841786).jpg (wiki Commons)

Architecture theorist and Mathematician, Nikos Salingaros, asks an important question about complexity in design. The examples given of fractal design are often overwhelmingly traditional and historic. He traces the contemporary dearth of visual complexity to the living legacy of Modernism and the influential thoughts of Adolf Loos and Le Corbusier. On this issue he comments:

> *"Thus they [Adolf Loos and Le Corbusier] condemned the material culture of mankind from all around the globe, accumulated over millennia. While these condemnations may seem actions of merely stylistic interest, in fact, they had indirect but serious consequences." (Salingaros, 2004, p. 79)*

Here he continues to speak of the consequences of removing complex, ordered patterns at the perceptible scale, the architectural (middle) and the interior/decorative (micro):

> *"The elimination of ornament removes all ordered structural differentiations from the range of scales 5mm to 2m or thereabouts… Looking around at twentieth century buildings, one is hard-pressed to discover visual patterns. Indeed, their [modernist] architects go to great lengths to disguise patterns on human scales..." (Salingaros, 2004, p. 79)*

Christopher Alexander, in his magnum opus, *A Patten Language,* takes on the issue of ordering and patterning. Alexander champions ornamentation, or visual complexity, as "extra binding energy" (Alexander, Ishikawa, Silverstein, & Al., 1977, p. 1151) that helps connects elements of a building at the micro scale.

The idea of a perceptible scale is one that reemerges with other researchers. In order to leverage the possible benefits of biophilic fractal patterns to our wellbeing, the scale of fractal implementations must correspond to the human experience. The urban scale and architectural scale are not easily perceived by the inhabitants. When immersed in a built

environment, interior space is the readily perceivable scale. The smallest scale of fractal manifestation – surface decoration and ornamentation – would be the most impactful, since it is readily perceivable and most immersive of all the scales. Joye speaks to the importance of scale, adding that intentionality of the designer in incorporating fractal pattern is critical (Joye, 2011). The author introduces both these ideas leading to an amended set of characteristics that describe fractals in design:

1. Fine structure, a cascade of detail
2. Irregular, hard to describe with Euclidian geometry
3. Self-similar, exact or statistical (mathematical or natural)
4. Can be described in a very simple way, recursion, translation, etc.
5. Intentionally applied
6. Scaled iteration
7. 3 time nested iteration of shapes

The author proposes to call fractal patterns that follow the above characteristics 'designer fractals'.

5 Methodology

To investigate the validity of these ideas, the following questions will be addressed in this research:

- Q 1: To what extent do the proven perceived wellbeing effects of statistical/natural fractals hold true for designer fractal patterns?
- Q 2: In what ways are forced choice protocols beneficial when assessing perceived effects of the design of interiors? What are the consequences of not utilizing methodologies that value ecological validity?

The disconnection between scientific data and practical application in design-related research can be investigated using a cross-disciplinary approach using cognitive psychology, environmental psychology, and physics. The aim of this approach is to show a connection between fractal patterns and positive wellbeing experiences (Bies, Blanc-goldhammer, Boydston, Taylor, & Sereno, 2016; Hagerhall et al., 2008; Taylor, 2006). However, the findings of such research are rarely incorporated into design practice. Firstly, the disconnect is due to the limited application scenarios that a designer can imagine from dry data. Secondly, the patterns used as stimuli in these scientific experiments, though providing the necessary visual complexity, do not conform to what a designer would consider aesthetically pleasing. On occasion, the fractal patterns used are drawn from line graphs showing market fluctuations as shown in Figure 8.

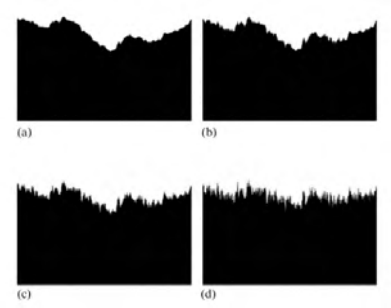

Figure 8. Fractal pattern used as visual stimulus in Hagerhall, et al. 2008, p.1491. This pattern is not one designers would consider aesthetically pleasing.

In my research, I address this disconnection in two ways. One, by using designer fractal patterns, in context within an interior environment, to measure and record the perceived wellbeing effects -in particular, to record positive vs. negative mood, visual interest, and visual preference. Examples of the designer fractal pattern I hope to use as visual stimuli in my research can be seen in Figure 9 and 10.

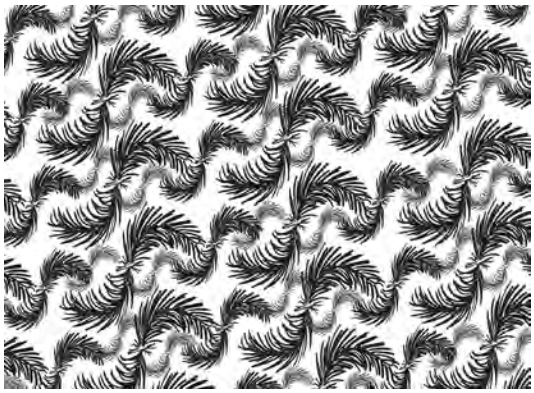

Figure 9. This pattern is modelled by the author after a pattern called "green Goose Waltz" designed by Robert Zakanitch, circa 1980. It is a pattern included in Anna Swartz's book Pattern & Decoration: An ideal vision in American Art. The pattern strikes a strong resemblance to a fractal referred to as a Dragon Curve.

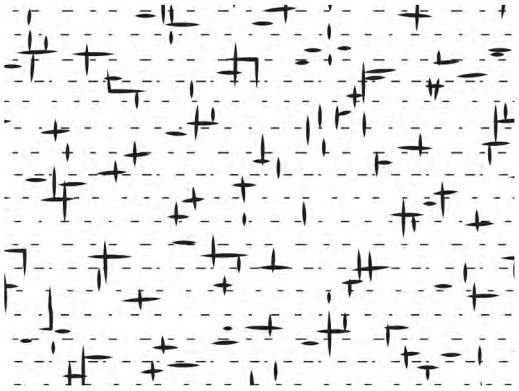

Figure 10. This pattern is modelled by the author after a pattern included in an abstract pattern anthology collected by Kyoto Shon. It bears a strong resemblance to fractal called a Cantor Set.

The second way I address the disconnect is by utilizing two different approaches to the methodology.

6 Steps Forward

The research plan includes two sessions that I will conduct.

The sessions are designed to collect responses to perceived wellbeing indicators: visual interest, visual preference and mood responses. The first session will enlist participants in a laboratory type experiment to rate the perceived wellbeing effects of several pattern swatches through a forced choice procedure, answering a prompt relating to each of the wellbeing indicators. The methodology is constructed to parallel the methodology used in precedence studies. Wherever a forced choice method would not be appropriate, a Likert scale will be used.

This second session will embrace a participatory mindset and prioritize ecological validity. The designer fractal patterns will be projected to cover an entire wall within a room. The participants in the room will be asked to communicate their perceived wellbeing. Several mapping activities will be carried out to establish responses to visual interest, visual preference and mood responses. Other responses will also be collected in this session such as spontaneous utterances, and observable behaviours.

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Preference for Fabric Types Under Various Lighting Colours

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This study is an investigation of the impact of lighting colours on the subjective judgments of fabric and, in particular, whether the influence of lighting would vary depending on the type of fabric. We conducted visual assessments for eight kinds of illuminants and six types of fabric presented as cloth stimuli (N = 44). Derived from the literature review, four sets of adjectives were used as metrics: humble/luxurious, cool/warm, old/new, and preference in general. The results showed that colours of lighting and cloth types influenced the participants' perceptions about the fabric. Overall, White4K(4000K) were the most preferred across various types of clothes, followed by Bluish-purple white and the White6K(6000K). Also, there were interaction effects between colours of lighting and types of clothes with regard to each of the perceptual qualities. For instance, when shirts were displayed under Bluish-purple white, participants evaluated them as luxurious and new, thereby reporting quite high levels of preference. This study provides empirical evidence to optimally match lighting colours with types of fabric in the presentation of textile goods.

Keywords: Colour, Fabric, Lighting, Preference

1 Introduction

Due to their diverse surface characteristics, the appearance of fabrics is highly influenced by lighting conditions. When fabrics are processed into clothes, the lighting becomes even more crucial. Regarding the influence of ambient lighting on the style of clothes, most studies have paid attention to the attractive presentation of apparel goods in merchandising spaces. The studies have mainly tackled the brightness, contrast, and hue nuances of interior lighting.

Supported by advances of light emitting diodes (LEDs), the investigations have been accelerated by expanded freedom in controlling lighting properties, including brightness, chromaticity, and dynamics. For example, Huang and his colleagues (2018), trying to establish the appropriate light for displaying blue jeans, suggested that ambient lighting with higher correlated colour temperatures (CCT[1]) around 5,500 K was preferred most. The study claimed that the blue hue of jeans appeared more vivid under the 5,500 K than other lighting

[1] CCT is a specification of the colour appearance of the light source, which is in relation to the temperature of an ideal black-body radiator that radiates light of a colour comparable to that of the light source. CCT is measured in degrees Kelvin (K) and ranges from red to orange to yellow to white to blueish white. A warm light is around 2700K-3000K, moving to neutral white at around 4000 K, and to cool white at around 5000 K or more. Although CCT is not related to the colour rendering ability of the light source, it plays an important role in humans' colour perceptions.

conditions (Huang et al., 2018), confirming that in general, a hue alignment between ambient lighting and an object derives a positive response.

Moreover, LEDs have enabled product designers to easily and freely imbed lighting as one of the form attributes of product design. Examples are found in automobiles and home appliances. Mercedes-Benz launched an incorporated ambience light into its 2016 E-Class sports cars, allowing drivers to select the hue of interior lighting, which is one of the leading trends in passenger cars. Also, a recent study evaluated the unique styles resulting from interactions between the colour of a cavity and the colour of the lighting (Han & Suk, 2019). In parallel, because such experiences are new, studies debate what to or how to measure the value (Jeong & Suk, 2018).

In this study, we investigated how people perceive the quality of clothes under various hues of light. We anticipated an interaction effect between fabric types of clothes and hue nuances of lighting on perceived quality. To observe participants' assessments, we conducted an empirical study and performed both quantitative and qualitative analyses to derive findings and insights.

2 Setup for visual assessment

For the visual assessment, we set up a viewing condition consisting of cloth stimuli (2.1), lighting conditions (2.2), and metrics (2.3) for participants to make subjective judgments. In assessments, to visualize the prototypical image of the fabrics more clearly, we used clothes rather than fabrics as such.

2.1 Cloth stimuli

Six kinds of fabric were taken into consideration for the cloth selection. We collected shirts, a fur stole, a down muffler, knitted sweater, and a tie and coat; their fabrics were polyester, genuine fox fur, cotton, acryl, silk, and wool, respectively. All clothes were purchased as pairs for a comparative study plan except for the coat, as the coat was big enough to cover two sections of a light booth. We also focused on the types of fabrics while minimizing the effects of the hue characteristics. When white clothes were not available, grey ones were chosen as alternatives. Figure 1 presents the clothes and their detailed fabric information.

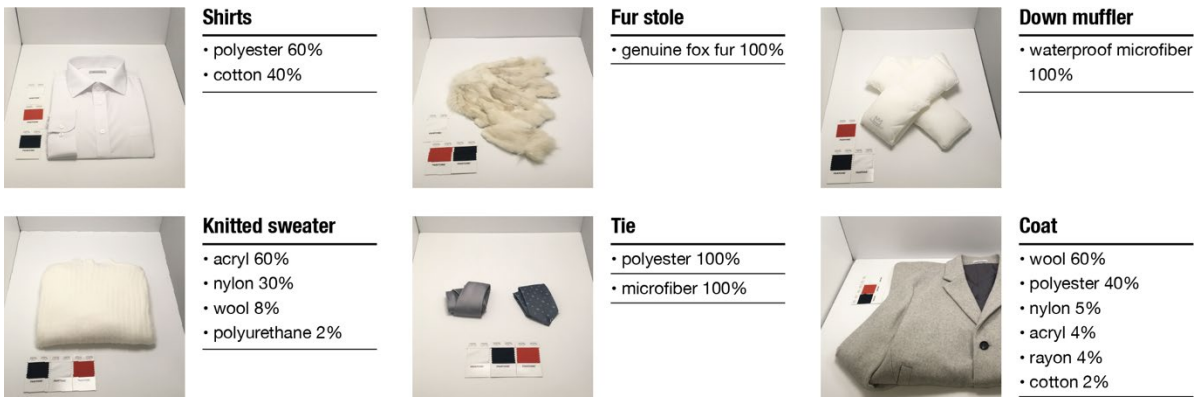

Figure 1. Six types of clothes, including a piece of fur from the fur stole.

2.2 Lighting conditions

We utilized a custom light box with a THOUSLITE LEDcube, a light booth that simulated lighting conditions according to the given spectral power distributions within the visible light

ranging between 350 nm and 800 nm. The booth allows either manual input or selection of pre-set lighting conditions, such as standard illuminants, from its database. The lightbox is made of steel plates and painted with N7 in the Munsell system. We divided the booth into two sections and manipulated the lighting separately (Figure 2).

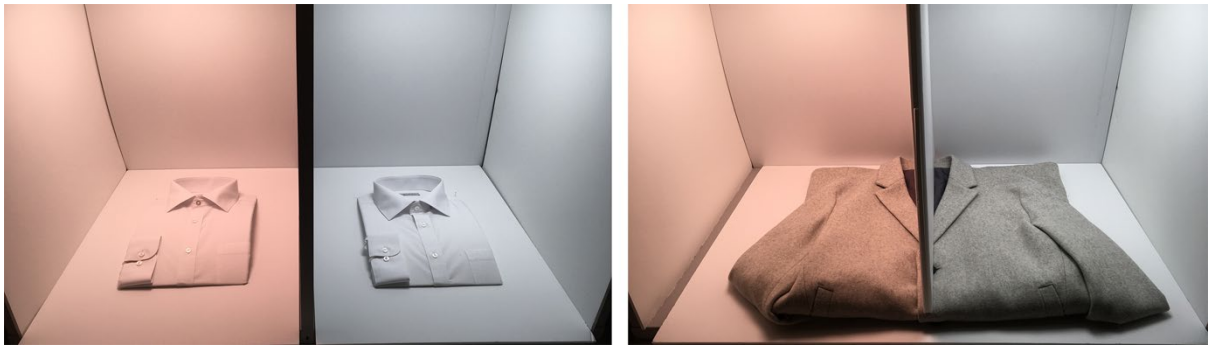

Figure 2. The LEDcube from Thouslite Ltd. Among the stimuli, a coat was displayed across the two sections with each booth lit differently.

In the light booth, we articulated eight chromaticity values which were selected within the white range of the 1931 Commission Internationale de l'Eclairage (CIE) chromaticity diagram (CIE, 1932). Four of the lighting styles—White3K(3000K), white4K(4000K), White6K(600K), White8K(8000K)—are almost on the Planckian locus, while the other four types of lighting cover hue categories, such as Yellow-green white, Bluish-green white, Bluish-purple white, and Pink white. The lighting properties are measured in the central location of the booth floor with a Chroma Meter. The eight colours of lighting appeared as Figure 3 shows. The illuminance of the light booth was fixed to 750 lx, corresponding to the brightness level recommended for a focused task by the KS A 3011. The light booth was placed in the centre of the experimental room, and the room was lit by LEDs (6500 K) from the ceiling. During the assessment, the curtains were closed to block out the daylight.

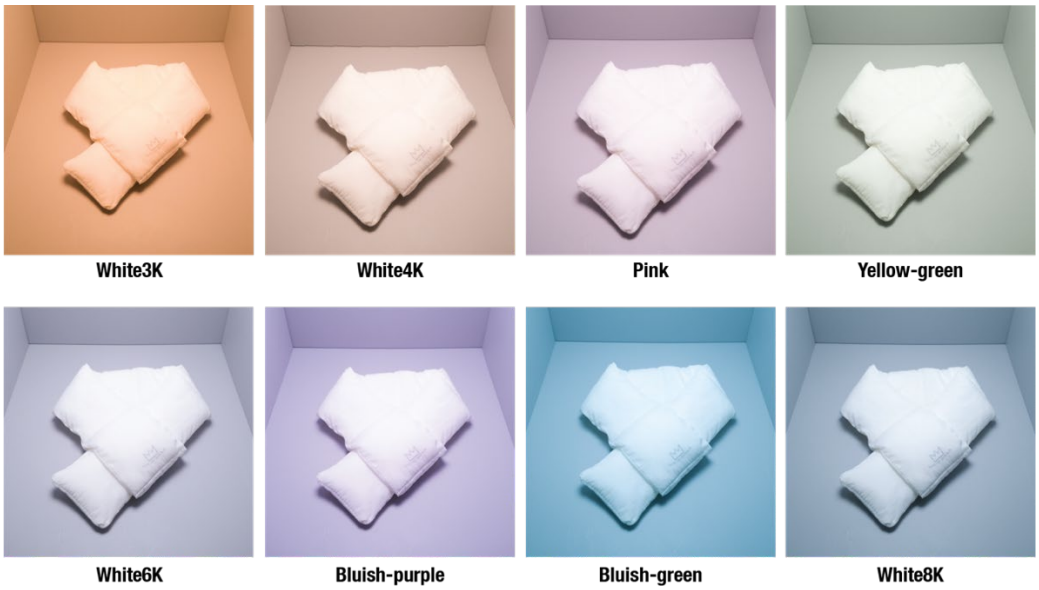

Figure 3. The eight lighting colours displayed in the LEDcube. The colours in the figure may look different than the actual lighting colours. The photos were taken with a Samsung Galaxy 6S in Pro (manual) mode.

2.3 Metrics of visual assessments

We developed a set of metrics to comprehensively observe subjective judgments of cloth-lighting combinations. Firstly, we collected style adjectives that were employed as metrics to make subjective judgments of textile styles, including clothes (Choi, Kim, & Cho, 2002; Chung, 2001; Kim & Lee, 2003; Lee & Kim, 2001; Nam, Lee, & Cho, 2003). We obtained a total of 168 adjectives. Secondly, we clustered the terms into groups of synonyms and narrowed the list to 30 adjectives. We excluded some terms (thick, wrinkled, shiny, fluffy, dry, active, and neat), because they are relevant only to particular types of fabric. Eventually, we selected 23 adjectives that were generally applicable to various fabric types and regrouped them again in four scales: humble/luxurious, cool/warm, old/new, and more holistically, preferred. In Table 1, the 23 adjectives and their membership to the four scales are summarized.

Table 1. The 23 adjectives derived from previous studies on fabric or cloth styles clustered into four bipolar scales.

23 ADJECTIVES *Some are bipolar pairs*	**4 BIPOLAR SCALES**
Fashionable, Elegant, Luxurious, Matured, Sophisticated, Impactful	**Humble - Luxurious**
Cool (- Warm), Rigid (- Soft, - Comfortable), Rationale (- Emotional)	**Cool - Warm**
Traditional (- Modern), Classic (- Contemporary)	**Old - New**
Appealing, Attractive, Favourable, Stylish, Likely to wear, Willing to purchase	**Not preferred - Preferred**

3 Visual assessment

3.1 Participants

A total of 44 participants (16 men and 28 women) were recruited, ranging in age from 20 to 41; the average age was 24.84 with a standard deviation of 5.67. The participants were recruited via an online university community; they were either university students or students' family members. Subjects were put into groups of three or four for experimental convenience. All subjects were paid volunteers, and each of them had normal or corrected-to-normal vision.

3.2 Procedure

As described in 2.2, a total of eight lighting conditions were prepared in the LEDcube light booth, and they were presented as pairs using the two divided sections within the booth. Consequently, four pairs of lighting were composed and shown to the participants in random order. Because of the chromatic adaptation of human vision, a sequential order of nuanced white lightings might not affect chromaticity—presenting pairs made the difference between the nuances of white lights more distinguishable. We placed identical clothing stimuli in both sections, allowing the participants to compare the effect of lighting on the style of cloth stimuli.

After instructions, participants made assessments on the given adjective scales printed on questionnaire sheets. The entire experiment took about 30-50 minutes depending on the participants' individual responding speed.

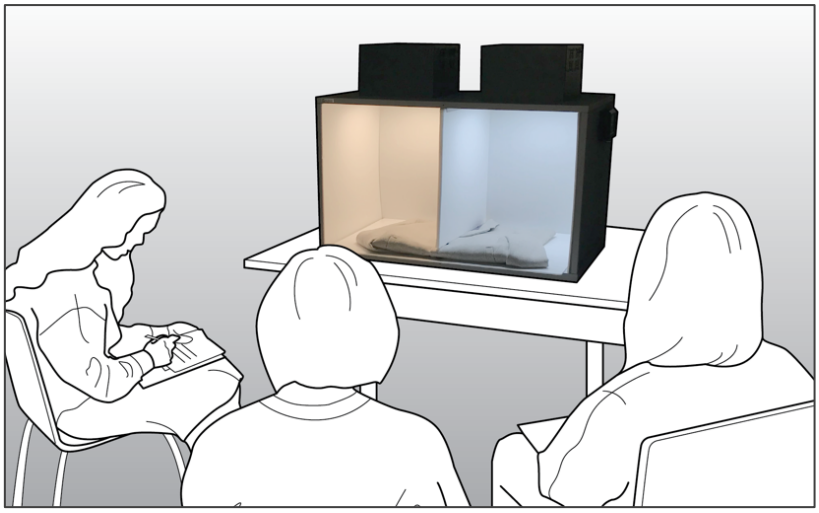

Figure 4. Procedure of the visual assessment.

3.3 Results

Based on the assessments, we conducted a quantitative analysis to figure out the influence of colours of lighting on the perceived quality of the six types of clothes. Considering colours of lighting and types of clothes as the two independent variables, we performed the two-way ANOVA with repeated measurement of the four metrics. Overall, we found statistically significant influences of both factors on all of the perceived qualities (see Table 2), where particular combinations showed stronger impacts on different aspects.

*Table 2. Statistical results of the two-way ANOVA with repeated measurement (N = 44). The two independent variables were colours of lighting and types of clothes. * p < .05.*

HUMBLE - LUXURIOUS	COOL - WARM	OLD - NEW	PREFERENCE
F(35, 1435) = 2.00*	F(35, 1435) = 1.88*	F(35, 1435) = 1.24*	F(35, 1435) = 2.57*

Table 3 presents the average scores of every combination with regard to preference; overall, White4K was the most preferred for all types of clothes, followed by Bluish-purple and White6K. In Table 3, where the impact is particularly noticeable, the cells are shaded in grey. For instance, fabric types typically associated with winter clothes, such as the fox fur stole and down muffler, were more preferred in warm white, i.e. White4K. Otherwise, Bluish-purple was preferred the colour of lighting for the daily items, such as the shirts and tie.

Table 3. Average scores of combinations between colours of lighting and types of clothes with regard to preference (N = 44). Cells are shaded in grey when the scores are higher than or equal to + 0.80.

-2: not preferred ~ +2: preferred

COLOURS OF LIGHTING	SHIRTS	FUR	DOWN	SWEATER	TIE	COAT
White3K	- 0.18	- 0.11	- 0.02	+ 0.16	- 0.32	- 0.11
White4K	+ 0.68	+ 0.95	+ 1.09	+ 0.98	- 0.32	+ 0.77
Pink	+ 0.48	+ 0.41	+ 0.57	+ 0.48	+ 0.30	+ 0.80
Yellow-green	- 0.30	- 0.89	- 0.25	- 0.80	- 0.61	- 0.68
White6K	+ 0.82	+ 0.57	+ 0.61	+ 0.70	+ 0.64	+ 0.75
Bluish-purple	+ 1.11	+ 0.45	+ 0.89	+ 0.73	+ 1.09	+ 0.50
Bluish-green	- 0.34	- 0.50	+ 0.27	- 0.57	- 0.45	- 0.66
White8K	+ 0.07	- 0.23	+ 0.27	- 0.09	- 0.02	+0.02

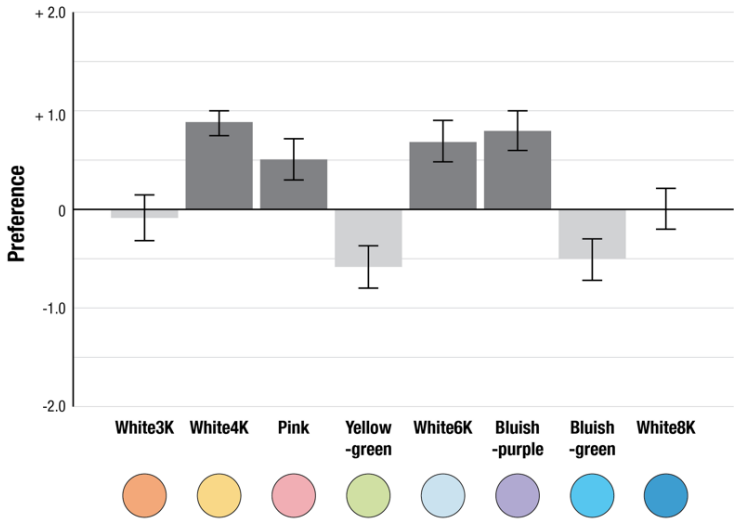

Figure 5. Average preference scores of the eight lighting colours across six types of clothes. Error bars indicate +/- standard error.

In this way, we identified the proper lighting colours with regard to the other two metrics, humble/luxurious and old/new. In both cases, four colours—White4K, Pink, White6K, and Bluish-purple—were more preferred than the other four (Figure 5). For a luxurious look, White4K was assessed to be the most adequate, while Bluish-purple was the ideal for expressing newness (Figure 6).

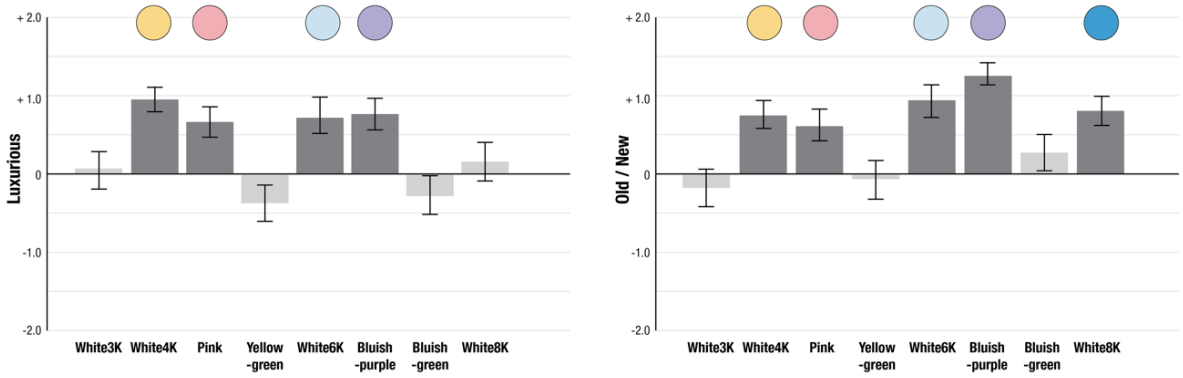

Figure 6. Average scores of the eight lighting colours across six types of clothes regarding luxurious (left) and new (right). Error bars indicate +/- standard error.

Moreover, we found that the colour of lighting affects the temperature perception of the clothes, too. Obviously, a low CCT gives a feeling of warmth, while a higher CCT generates a cooler feeling, especially when the lighting follows the Planckian locus. Occasionally, when the chromaticity of the lighting is far from the locus (e.g. Yellow-green), its CCT was unrelated to temperature perception.

4 Discussion

With the advances in lighting sources and their control technology, designers have more freedom to select the optimal light for showcasing their work. This concept is not limited to the fashion industry; it is highly demanding to find the best lighting to display textile surfaces more attractively. This study was intended to establish the optimal matches between colours

of lighting and types of fabric. Particularly, we examined the effect of colour of lighting, not only varying the CCT of the light but also covering diverse hue categories, such as Yellow-green, Pink, Bluish-purple, and Bluish-green. Because those chromatic lightings were distanced from the Planckian locus, they were not considered natural light. Including these, we used eight types of lighting in the LEDcube and presented six types of clothes. The six pieces of clothing were typical items made out of each fabric type.

Based on the assessments, we figured out that the perceptual quality of fabric was influenced by the colour of lighting, and the optimal lighting conditions depended on the type of fabric. For example, when the fox fur stole was displayed under White4K light, it appeared the most luxurious. Bluish-purple light was found to be the most effective at making white shirts look fresh and new. In general, across the fabric types, White4K, White6K, and Bluish-purple were evaluated positively, while Yellow-green, Bluish-green, and White3K were evaluated negatively. This trend is not aligned to the conventional understanding of good quality of lighting; i.e., that natural light is always better. Bluish-purple was one of the most preferred lighting colours, as it successfully enhanced the freshness of white clothes, although it may have failed to render perfect yellow or orange hues. This implies that CCT variation is insufficient to explore the best colours of lighting.

However, the empirical results were limited to clothes in white and light grey. When a fabric has particular hue characteristics, we can anticipate interactions between the hue of fabric and that of the lighting. Also, the study did not simulate any specific context, such as a retail setting space or closet. As found from the visual assessment, optimal lighting varies depending on what aspect is being evaluated. In line with this, additional metrics should be included when a particular context is targeted.

Nevertheless, this study contributes to a set of knowledge that designers can refer to when proposing colours of lighting. The empirical findings provide evidence to support designers' claims when the evidence is aligned to the concept. When it differs, it is still helpful because designers should take into consideration how users perceive products. Through an expansion of fabric types and assessment metrics, researchers expect to find more cases of synergy between colours of lighting and textile goods.

5 Conclusion

Visual assessments were conducted with 44 participants to establish a synergetic combination between colours of lighting and types of fabric. Eight kinds of illuminant were generated, and six types of fabric were presented as cloth stimuli. Based on the literature review on styles of textiles, we collected 168 terms and narrowed down them into four metrics: humble/luxurious, cool/warm, old/new, and preference in general. The statistical analysis showed that colours of lighting and clothing types influenced the participants' perceptions of quality. Overall, White4K was the most preferred for various types of clothes, followed by the lights with Bluish-purple and White6K. Also, there were interaction effects between colours of lighting and types of clothes with regard to each of the perceptual qualities. For instance, when shirts were displayed under Bluish-purple light, participants evaluated them as luxurious and new, thereby reporting quite a high level of preference. This study provides empirical evidence to optimally match colours of lighting with types of fabric when presenting textile goods appropriately for specific concepts.

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Research on the Influence of Wheel Type on the Visual Image of Urban Bicycle

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As green vehicles, urban bicycles play an important role in releasing urban traffic pressure and promoting energy conservation and emission reduction. The research is designed to evaluate the visual image of wheel types in the urban bicycles. Due to the variety of wheels, 10 models with high market share are taken as research samples. First, the 2D images of 10 types of wheels are drawn by the drawing software Photoshop. Six sets of visual image adjectives obtained by factor analysis are used to conduct a questionnaire survey to collect consumer visual evaluation of ten types of wheels. Then, the obtained data is further calculated by the triangular fuzzy number of the fuzzy theory, and the evaluation scores of the ten types of visual images are obtained. The research results show that the visual image evaluation of different types of wheels distinguish in "trimmed and stable", "superior and presentable" and "holistic and balanced", while little differ in "novel and individualized" and "rhythmic and metrical". In addition, the four visual groups of the overall visual image evaluation are compared from the sample by the qualitative classification. The results of the visual evaluation can effectively reflect the potential preference of urban residents for type of wheel of urban bicycles, which can be used by relevant operators and help to improve the design efficiency of the product development stage.

Keywords: urban bicycle; wheel type; visual evaluation; fuzzy logic; Factor analysis

1 Introduction

In recent years, with people's concept changing, saving energy and protecting the environment is deeply rooted in the hearts of the people's mind around the world. As important means of transportation in the city, bicycles are green and health products that are energy-saving and environmentally friendly. It can save the significant social resources since the usage of bicycles does not require asphalt paved roads. Besides, urban bicycles can't cause traffic congestion and serious traffic accidents due to their small size and slow speed. At present, many crowd funding companies have participated in the promotion of urban bicycles and have produced various types of urban bicycles. However, urban bicycles users are a large number of non-professional consumers who do not have a strong demand for the functionality of bicycles. Instead, they are more concerned with the user experience and appearance of urban bicycles. Therefore, designers should try their best to meet the potential psychological needs of consumers and shift the focus of design to the appearance

design of urban bicycles. Among the components of the bicycle, the wheel, the handle, the frame, the seat cushion and crank affect the consumer's preference for the bicycle(Hsiao & Ko,2013), wherein the wheel set can be regarded as one of important components in the bicycle appearance due to its large area.

More and more urban residents tend to use urban bicycles in the world. Scholars such as Murphy and Usher (2015) conducted a questionnaire survey on the use of urban bicycles by Irish citizens. In 360 valid questionnaires, urban bicycles were accepted by middle and high income people. Shaheen, Zhang, Martin, and Guzman (2011) surveyed 806 citizens in Hangzhou, and 30% of them said that they would include cycling shared bicycles in their transportation mode. According to a survey by Chinese scholar Zhu (2018), the official website statistics of Mobike show that as of June 2017, Mobike shared more than 100 million registered bicycle users, with a market volume of more than 5 million vehicles and covering more than 100 cities. What's more, according to public data, the number of bicycles in Beijing has reached 200,000, and the total number of shared bicycles in Shanghai has exceeded 360,000. The shared bicycles in Guangzhou and Shenzhen are not to be underestimated, with nearly 200,000 and 320,000 respectively. The penetration rates reached 1.5%, 0.9%, 1.4%, and 2.8%, respectively (Li,2017).

Urban bicycles have many brands, of which only a dozen shared in the Chinese market, which are differences between the wheel types of each brand. Different types of wheels for the design of urban bicycles will bring different psychological feelings for customers, which in turn will affect their preferences in subjective shape of urban bicycles. In the development and design stage of new products, designers usually rely on their own accumulation of aesthetic perception and experiences. Although the designer can interpret the shape, color or material in the design expression, consumers still have different feelings in their mind, and the feelings would affects the consumer's judgment on product preferences. Therefore, if we can conduct an investigation and analysis of the different visual psychological feelings of different types of wheels and people by objective research methods, and explore the user's visual image evaluation of various wheels. On the one hand, it will help to narrow the gap in the perception of wheel types for designers and users. On the other hand, it can also improve the design benefits of urban bicycles, and provide the help for related businesses, designers and consumers.

As for the study of vision and imagery, Arnheim (1969), a well-known American aesthetic intuition psychologist, the late representative of Gestalt psychology clearly pointed out: "Vision is a very active form of feeling", "A positive choice is a basic feature of vision, just as it is the basic feature of other sensible things." Zhang (1986), a professor of Chinese psychology, in his book "Feeling Psychology" edited in the 1940s, pointed out: "Vision is the most powerful in all human feelings, followed by hearing." The scope of the world is limitless, and the world culture and progress depend more on vision." Regarding the interpretation of imagery, Peng (2000) believes that imagery is a symbol or representation, representing a certain object or event, and the information that is transmitted has distinct perceptual characteristics. Del Bimbo, Pala, and Santini(1994) pointed out that the image is obtained through the similarity between the imagination of the shape of the object and the sketch drawn by the user. Therefore, the complexity of the shape of the object that the user feels is in fact impossible to define it accurately by numbers.

Regarding the related research on bicycle shape design, Pan and Lei (2017) takes the Mobike as an example, and clearly defines the bicycle design oriented by “shape and innovation”, which will be well received by the market. Hsiao and Ko (2013) proposed an evaluation model for product shape. Through this evaluation model, consumers' preference for bicycle components can be obtained. The questionnaire survey results of 89 subjects show the importance of five evaluation items, namely: “handlebar”, “saddle”, “frame”, “wheel set” and “chainwheel set and crank”, Although the wheelset is of the least importance in this study, its area is the largest among all components, which deserves further study. This research is aimed at the Chinese market. In comparison, the type of the research sample is richer and modern with more design. Therefore, it is necessary to further study the influence of the wheel set on the appearance of the bicycle. Lin, Ho, and Xia (2018) focuses on the frame image of shared bicycles in Hangzhou, and evaluates and classifies various frame types through semantic difference method and factor analysis to ensure reasonable allocation and use of shared bicycles in Hangzhou. Hsiao, Chen, and Leng (2015) proposed a method for measuring the comfort of riding, and applied it to the design of bicycles, which can help consumers of different heights to choose the suitable bicycles. Due to the differences in the wheel types of different brands of urban bicycles, this research mainly focuses on the wheel types of urban bicycles, trying to explore the influence of different types of wheels on the visual image of bicycles. The research not only help consumers to purchase bicycles with their aesthetic needs, but also help designers to choose the wheel type that suits different styles in the development phase of new bicycles.

In summary, the average consumer has different sensory values for different wheel types. Therefore, the research aims to investigate and analyze different wheel types and different visual psychological feelings of consumers through objective research methods. The influence of the pattern on the visual image of urban bicycles is analyzed by appropriate image adjectives to compare the visual images of different wheel types. Next, the fuzzy number calculation method in fuzzy theory is used to analyze the visual image evaluation of various wheels. Finally, the research results are supposed to be reference for relevant operators, designers and consumers.

2 Materials and methods

2.1 Research framework

This research takes the shape of urban bicycle wheels as the research object. The main research process is shown in Figure 1. First, collect adjectives related to the visual imagery of the wheel type. Urban bicycles are still a hot topic in Chinese society today. The research on various components of bicycles has accumulated many achievements. Some scholars have studied the visual image of bicycle frames. Therefore, this study refers to relevant paper research and product design related information (for example Shared bicycle official website) and related news networks (such as Tencent News and Today's headlines) as the main source of the collection of words. Finally, the adjectives suitable for expressing the image of bicycle wheel type are selected, and 110 adjectives are summarized and used as the consumer survey questionnaire of this study.

At the meanwhile, different types of wheels were collected as research samples. Through market research, we found that there are many types of bicycles in the city. In order to ensure the rigor and objectivity of the research, we chose urban bicycles with high market

share at home as research samples, and comprehensively considered the relevant data of their users' registration and service. After sorting out the statistics, it was decided to take the top 10 types of wheels of the market share as the research samples and randomly number them, as shown in Table 1.

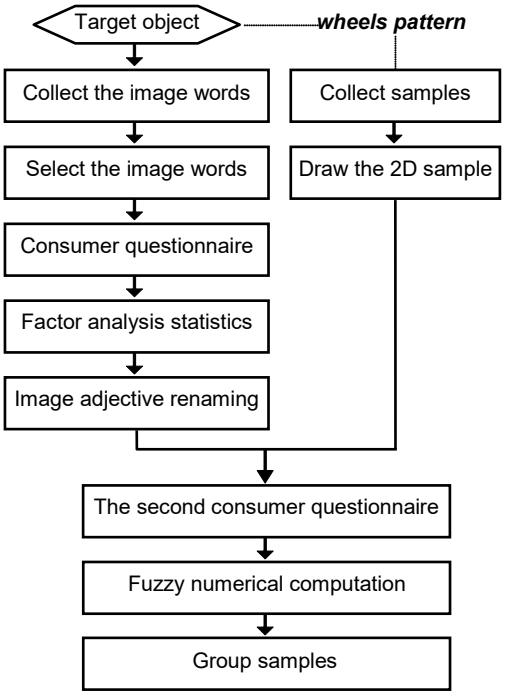


Figure 1. Research flowchart.

The research selects the image word by expert questionnaires, and invites 10 designers and college teachers related to product design as the subjects. Subjects are asked to subjectively screen out 40 to 50 adjectives that best fit the wheel image in the 110 image vocabulary provided by the questionnaire, and then sort out the top 40 adjectives with the highest number of scores in a number-average manner. Used as a follow-up study.

In order to further reduce the number of adjectives, the 40 adjectives obtained from the expert questionnaire were used to conduct a questionnaire survey on the semantic differences of urban bicycle consumers through the Likert Five-Point Scale Questionnaire. Factor analysis was conducted on the questionnaire survey data using SPSS, and then renaming each group of adjectives. The five grades in the scale included “very unsuitable”, “unsuitable”, “ordinary”, “suitable” and “very suitable”, and a total of 104 valid questionnaire samples (47 males, 57 females) were obtained.

According to Table 1, 10 types of urban bicycle wheel images were collected, and 2D images were drawn by Photoshop plane drawing software. As shown in Figure 2, the second consumer questionnaire was conducted with the renamed wheel type visual image adjectives survey. The frame, handlebar, saddle and crank image samples used in the questionnaire were selected according to the principle of simplicity. During the questionnaire survey, the subject used the finger to slide the screen left and right to replace the different types of wheels, as shown in Figure 3. Then the questionnaire results are numerically calculated by fuzzy theory, and then the graphs are drawn with various values for further comparative analysis.

Table 1 The numbers of the 10 species of bicycle wheel type.

No.	Name of Urban bicycle	Code	No.	Name of Urban bicycle	Code
1	Xiaoming	XM	1	Other 1	OT_1
2	Mobike	MB	2	Hellobike 2	HB_2
3	Hellobike 1	HB_1	3	Other 2	OT_2
4	Ofo	OF	4	Bluegogo	BG
5	Youon	YH	5	Other 3	OT_3

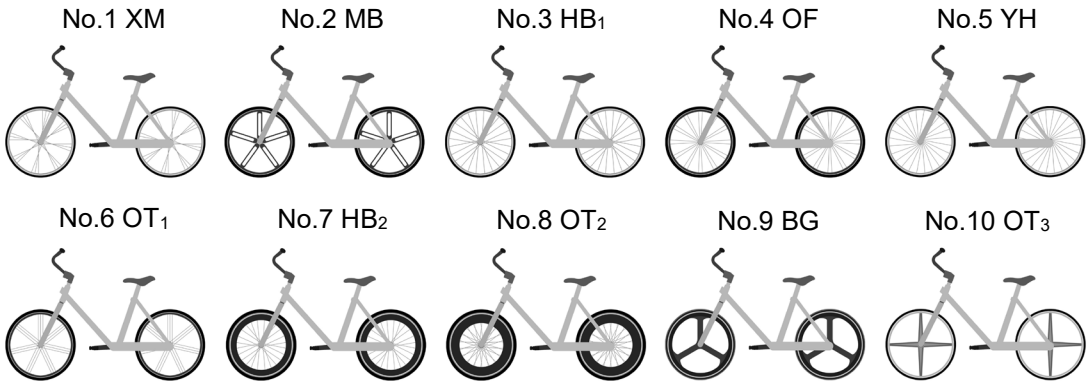


Figure 2. The 2D pictures of the 10 species of bicycle wheel type.

Figure 3. The survey of examinees on the virtual images of Mobike (MB).

2.2 Factor analysis

Factor analysis is generally used to simplify complex data (Kline,2014), a method to quantitatively determine the direction and extent of influence of various factors on analytical indicators (Brown, Cash, & Mikulka,1990). Brown defines factor analysis as "a statistical method for determining how many factors are needed to explain the association between a set of variances. One factor is the combination of multiple associated variables, so the same characteristics can be measured "(Brown,1983). In other words, factor analysis can use less dimension to represent the original data structure and retain most of the information that the original data can provide. Hu and Liao (2010) integrated factor analysis and two-step cluster analysis to explore the user's evaluation of product style, confirming that factor analysis is an objective and effective research method. Therefore, this method is still used in this study.

2.3 Fuzzy logic

Fuzzy theory is a scientific method used to study and deal with fuzzy phenomena. Fuzzy theory has published for more than 50 years since it was first proposed. L.A. Zadeh, a professor at the University of California, Berkeley, proposed in 1965. It was often used to deal with inaccurate (inexact) fuzzy data, in the fuzzy environment through the rigorous mathematical calculations to solve the problem of decision-making (Zadeh,1965). Zadeh believes that human subjective thoughts, reasoning and perception of things around him have a certain degree of ambiguity in nature, so it is necessary to use fuzzy logical concepts to describe the merits of things in order to make up for the past traditional set theory. Binary

logic is used to describe the shortcomings of things, and to expand the relationship between elements and sets in traditional set theory. The membership function is used to represent the relationship between elements and sets (Zadeh,1975).

Fuzzy theory is applied to the measurement of semantic meaning. Fuzzy numbers usually expresses the method. The fuzzy numbers often used in research have the following types: Triangular fuzzy number, Trapezoidal fuzzy number, and Normal fuzzy number, among which triangular fuzzy number is the most common. The particularity of a triangular fuzzy number lies in its membership function, and the distribution of its possibilities is to form a triangle (Dubois & Prade,1978). Suppose $\tilde{t}$ is a triangular fuzzy number in function $\mu_{\tilde{t}}(x)$, expressed as $\tilde{t} = (t_1, t_2, t_3)$, when t_1, t_2 and t_3 are real numbers and $t_1 \leq t_2 \leq t_3$. In related research, Hsiao and Tsai (2005) integrated triangular fuzzy numbers, neural networks and genetic algorithms to propose a method that can be used to automatically generate product shapes and evaluate product imagery. Chen, Lee, and Lin (2014) used the triangular fuzzy numbers in fuzzy theory to obtain the scores of 12 kinds of wooden floors in 6 sets of visual image adjectives. Wang et al. (2017) believes that in many practical applications, it is often difficult to evaluate the failure efficiency of events that have occurred in the past. A new fault tree analysis method based on triangular fuzzy numbers is proposed to evaluate the failure efficiency of past events more efficiently.

This research uses the evaluation of semantic variables to help consumers express their judgments, so as to determine the order of the importance of user needs and wheel type sample selection. As shown in Table 2, the seven levels of semantic variables are: (1) Very Low (2) Low (3) Medium Low (4) Medium (5) Medium High (6) High (7) Very High. For the entire semantic scale, if the semantic variable is represented by its corresponding triangular fuzzy value, as shown in Figure 4, the triangular fuzzy number can be used to describe the relationship between potential traits and semantic terms.

Table 2 Linguistic variables for the importance and the ratings.

Linguistic variables	Triangular fuzzy numbers
Very low(VL)	(0,0,1)
Low(L)	(0,1,3)
Medium low(ML)	(1,3,5)
Medium(M)	(3,5,7)
Medium high(MH)	(5,7,9)
High(H)	(7,9,10)
Very high(VH)	(9,10,10)

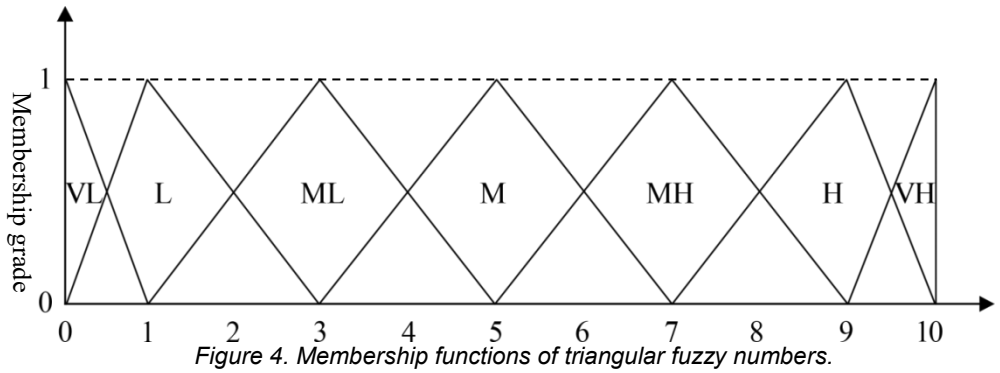


Figure 4. Membership functions of triangular fuzzy numbers.

2.4 Total utility value on triangular fuzzy numbers

In order to facilitate further comparison and analysis, the triangular fuzzy number in the membership function can convert into a crisp value by using the defuzzification, and the method used in the defuzzification is more commonly used "center of gravity", "maximum degree of membership" and "maximum set and minimum set method", among which "maximum set and minimum set method" are most commonly used. This study uses maximizing set and minimizing set method, which is used to calculate the weight of two triangular fuzzy numbers, and further derives the calculation method of returning the triangular fuzzy number to the total utility value. The absolute utility value used to calculate the fuzzy number is as follows:

Suppose that there are n triangular fuzzy numbers in the membership function of the triangular fuzzy number, which is defined as $\widetilde{t}_i = (t_{i1}, t_{i2}, t_{i3})$, i=1, 2, ..., n, so it can be concluded that the minimum membership function $\mu_G(x)$ and the maximum membership function $\mu_M(x)$ are G and M, respectively. thus, the total utility value formula, that is, $U_T(\widetilde{t}_i)$, of triangular fuzzy number $\widetilde{t}_i$ is shown in Equation (1):

$$U_T(\widetilde{t}_i) = \left[(t_{i3} - X_{\min})/((X_{\max} - X_{\min}) + (t_{i3} - t_{i2})) + 1 - (X_{\max} - t_{i1})/((X_{\max} - X_{\min}) + (t_{i2} - t_{i1}))\right]/2, i = 1,2,...,n \quad (1)$$

This research based on a questionnaire survey designed by fuzzy semantics theory to understand the consumer's visual image evaluation of 10 wheel types. The results are calculated by the numerical formula of the above fuzzy theory to calculate the visual image of each type of wheel. After the absolute utility value, the chart is drawn with various values, and the visual image of the 10 wheel types is further analyzed. The results can provide reference for the city bicycle related industry and consumers, in order to get the most suitable consumer demand.

3 Results and discussion

The 40 adjectives with the T test applied to the first factor analysis. After the principal component analysis, the first 16 adjectives whose absolute value of factor loading is greater than 0.6 are taken and the result of factor loading analysis is shown in Table 3.

Table 3 The 16 adjectives whose absolute values of factor loading were rank in the front.

Adjectives	Initial	Extraction	Adjectives	Initial	Extraction
Trimmed	1.000	0.769	Presentable	1.000	0.800
Regular	1.000	0.728	Rhythmic	1.000	0.834
Stable	1.000	0.723	Metrical	1.000	0.821
Interesting	1.000	0.785	Novel	1.000	0.747
Mechanical	1.000	0.729	Balanced	1.000	0.799
Ordered	1.000	0.849	Holistic	1.000	0.605
Individualized	1.000	0.774	Secure	1.000	0.771
Superior	1.000	0.740	symmetrical	1.000	0.689

The results of KMO and Bartliett tests after factor analysis showed that the KMO value was 0.735, indicating the datum was suitable; and Bartliett’ s spherical test value was 633.345 (degree of freedom 136), which was significant, representing a common factor among the matrices of the parent population.

The total variation of Table 4 shows that the eigenvalue of six factors were greater than 1, and the total variance explained was 76.008%, as shown by the transform matrix in Table 5. It is very clear that no other factor components are covered; therefore, 16 adjectives (such as Table 5) and 6 components (such as Table 4) of this factor analysis will be used in the follow-up.

Table 4 Total variance explained.

Factor of component	Initial eigenvalues			Squares loading extraction			Transformed squares loading		
	Total	Variance (%)	Accumulative (%)	Total	Variance (%)	Accumulative (%)	Total	Variance (%)	Accumulative (%)
1	4.831	30.195	30.195	4.831	30.195	30.195	2.2642.198	14.152	14.152
2	2.062	12.886	43.081	2.062	12.886	43.081	2.1751.985	13.735	27.887
3	1.509	9.431	52.512	1.509	9.431	52.512	1.9841.556	13.593	41.480
4	1.329	8.304	60.816	1.329	8.304	60.816	2.2642.198	12.406	53.886
5	1.307	8.166	68.981	1.307	8.166	68.981	2.1751.985	12.398	66.284
6	1.124	7.026	76.008	1.124	7.026	76.008	1.9841.556	9.724	76.008

Table 5 Transformed component matrixes.

Adjectives	Component					
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Presentable	0.794	-0.022	0.088	0.013	0.388	0.100
Secure	0.789	0.290	0.171	-0.114	-0.011	0.151
Superior	0.675	0.194	0.345	0.317	0.005	-0.163
Balanced	-0.034	0.778	0.230	0.137	0.314	0.148
symmetrical	0.131	0.769	-0.002	0.118	0.244	0.080
Holistic	0.231	0.726	0.075	0.095	-0.089	0.040
Interesting	0.076	0.069	0.818	0.184	0.240	-0.114
Individualized	0.133	0.030	0.789	-0.099	0.073	0.344
Novel	0.406	0.233	0.713	0.016	-0.068	0.117
Trimmed	-0.023	0.356	0.131	0.790	-0.013	-0.003
Regular	-0.135	0.065	-0.110	0.753	0.269	0.233
Stable	0.446	-0.022	0.110	0.700	0.047	0.136
Metrical	-0.002	0.123	0.139	0.227	0.855	0.060
Rhythmic	0.253	0.196	0.068	-0.011	0.852	0.031
Ordered	0.035	0.324	-0.054	0.098	0.236	0.822
Mechanical	0.110	-0.036	0.304	0.206	-0.106	0.755

3.1 Renaming results of factor analysis

In this research, we first obtain a description of the word vocabulary suitable for the evaluation of wheel type visual image, a total of 110 adjectives, so factor analysis was applied to select adjective groups, which included 16 adjectives and six factors. Therefore, at this stage, the factors are renamed through the association of the words in the various factor groups. The results are shown in Table 6, There are six adjective phrases, including Superior and Presentable, Holistic and Balanced, Novel and Individualized, Trimmed and Stable, Rhythmic and Metrical, and Mechanical and Ordered for the following consumers questionnaire survey on the visual evaluation of the 10 types of wheels.

3.2 Evaluation of visual images for wheel type

The 10 wheel types of urban bicycle in Table 1 were collected. Combining with the aforementioned six visual image adjective phrases, the triangular fuzzy number scale, in Table 2 were applied to the scale questionnaire design, and a questionnaire survey for consumers' visual evaluations of the 10 types of wheels was conducted. The seven-level scales are Very Low (VL), Low (L), Medium Low (ML), Medium (M), Medium High (MH), High (H) and Very High (VH). The questionnaires were collected through the above seven

evaluation levels, and the corresponding scores were obtained based on the triangular fuzzy numbers. As a result, 90 valid samples were obtained, and the subjects (male 50, female 40) were 20-40 years old, and urban bicycles were often used in daily life. The mean scores of visual evaluations of each wheel type are listed in Table 7 by fuzzy numerical computation. The visual evaluations of those wheel types were then sorted and diagrams were plotted by triangular fuzzy numbers, as shown in Figure 5.

Table 6 Factor renaming list.

Factor	Adjective groups	Factor naming	Code
Factor 1	Presentable; secure; superior	Superior and Presentable	S&P
Factor 2	Balanced; symmetrical; holistic	Holistic and Balanced	H&B
Factor 3	Interesting; individualized; novel	Novel and Individualized	N&I
Factor 4	Trimmed; regular; stable	Trimmed and Stable	T&S
Factor 5	Metrical; rhythmic	Rhythmic and Metrical	R&M
Factor 6	Ordered; mechanical	Mechanical and Ordered	M&O

Table 7 The sequence and means of the visual evaluations of the species of wheel type.

Wheel species	Superior and Presentable	Holistic and Balanced	Novel and Individualized	Trimmed and Stable	Rhythmic and Metrical	Mechanical and Ordered
XM	(4.0 5.9 7.6)	(3.9 5.9 7.7)	(3.9 5.8 7.5)	(3.4 5.3 7.1)	(4.5 6.4 8.1)	(4.4 6.3 8.0)
MB	(4.9 6.8 8.4)	(4.9 6.8 8.4)	(4.9 6.8 8.4)	(4.9 6.8 8.4)	(4.8 6.7 8.3)	(4.7 6.6 8.3)
HB1	(3.8 5.6 7.3)	(4.5 6.4 8.1)	(4.3 6.1 7.9)	(2.9 4.6 6.4)	(4.0 5.9 7.6)	(4.2 6.1 7.9)
OF	(4.4 6.4 8.2)	(4.9 6.8 8.5)	(4.6 6.6 8.3)	(3.8 5.7 7.5)	(4.5 6.4 8.2)	(4.2 6.2 8.0)
YH	(4.2 6.1 7.8)	(4.5 6.4 8.0)	(4.2 6.1 7.8)	(4.1 6.0 7.8)	(4.7 6.6 8.2)	(4.4 6.3 8.1)
OT1	(4.5 6.4 8.1)	(4.7 6.6 8.3)	(4.3 6.3 8.0)	(4.8 6.7 8.3)	(4.6 6.5 8.2)	(4.2 6.1 7.9)
HB2	(3.1 4.8 6.6)	(3.2 5.0 6.8)	(4.0 5.9 7.5)	(4.2 6.1 7.8)	(3.4 5.3 7.1)	(3.4 5.2 7.0)
OT2	(3.1 4.9 6.6)	(3.5 5.2 6.9)	(3.9 5.7 7.4)	(4.1 5.9 7.5)	(3.4 5.3 7.0)	(3.7 5.5 7.2)
BG	(4.9 6.7 8.4)	(4.7 6.5 8.1)	(5.1 7.0 8.5)	(5.5 7.2 8.5)	(4.9 6.7 8.3)	(4.7 6.5 8.1)
OT3	(4.0 5.7 7.4)	(3.6 5.4 7.1)	(3.4 5.1 7.0)	(4.8 6.6 8.0)	(3.9 5.7 7.5)	(3.6 5.4 7.2)

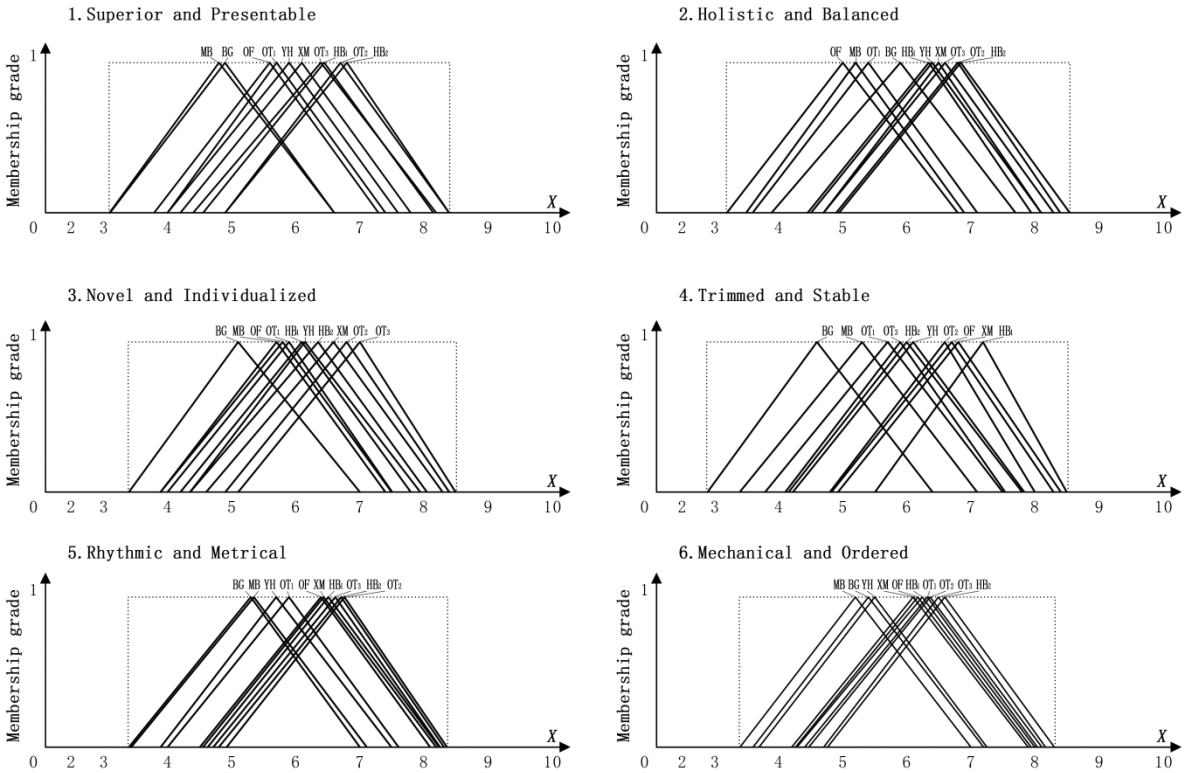
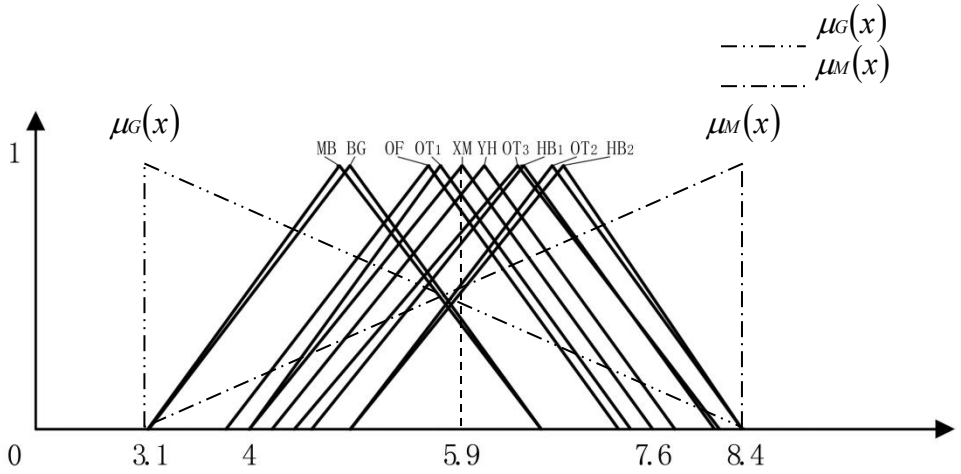


Figure 5. The triangular fuzzy numbers of the 10 species of wheel type in each visual evaluation. All abbreviations for wheel type species are referred to Table 1.

The triangular fuzzy numbers of each visual evaluations of 10 wheel types were converted into the absolute utility value of evaluation. Based on the data in Table 7 and Figure 6, the absolute utility value formula of the triangular fuzzy number $\tilde{t}_i$ is used. The abbreviation of the wheel name is shown in Table 1. For example, the calculation of sample 1 (XM) in the visual evaluation of "Superior and Presentable" is as follows:

$$U_T(\tilde{t}_i) = \left[(t_{i3} - X_{\min})/((X_{\max} - X_{\min}) + (t_{i3} - t_{i2})) + 1 - (X_{\max} - t_{i1})/((X_{\max} - X_{\min}) + (t_{i2} - t_{i1}))\right]/2, i = 1,2,...,n \quad (1)$$

Incorporate $\tilde{t}_1 = (4.0,5.9,7.6)$, $X_{\max} = 8.4$, $X_{\min} = 3.1$ into Equation (1) to calculate $U_T(\tilde{t}_1)$, the result is：



$$U_T(\tilde{t}_1) = \left[(7.6 - 3.1)/((8.4 - 3.1) + (7.6 - 5.9)) + 1 - (8.4 - 4)/((8.4 - 3.1) + (5.9 - 4))\right]/2 = 0.4240$$

Figure 6. The triangular fuzzy numbers of the 10 species of wheel type in the visual evaluation of "Superior and Presentable". Abbreviations for wheel type species are referred to Table 1.

The total utility values of the visual evaluations of 10 wheel types after calculation are shown in Table 8.

Table 8 The visual evaluation values of 10 species of wheel type.

Superior and Presentable	Holistic and Balanced	Novel and Individualized	Trimmed and Stable	Rhythmic and Metrical	Mechanical and Ordered	Superior and Presentable
XM	0.4240	0.5018	0.4729	0.4002	0.5766	0.5617
MB	0.6410*	0.6268*	0.6160	0.6419*	0.6196	0.6065*
HB1	0.4761	0.5722	0.5217	0.3529	0.5020	0.5344
OF	0.5852	0.5591	0.5856	0.4975	0.5788	0.5462
YH	0.5440	0.5700	0.5164	0.5377	0.6045	0.5640
OT1	0.5863	0.6004	0.5425	0.6163	0.5916	0.5344
HB2	0.3679	0.3803	0.4845	0.5489	0.4158	0.4030
OT2	0.3732	0.4071	0.4608	0.5221	0.4124	0.4446
BG	0.6321	0.5875	0.6435*	0.6279	0.6232*	0.5929
OT3	0.5000	0.4335	0.3821	0.6143	0.4776	0.4328

** highest scores of species in each evaluation factor For abbreviations of visual images, refer to Table 1.*

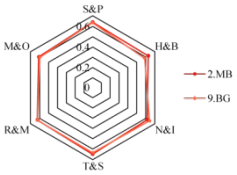
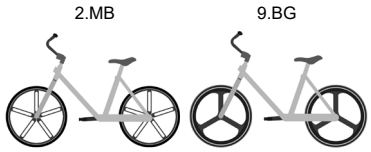
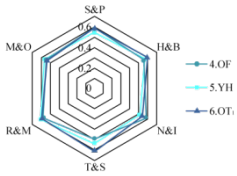
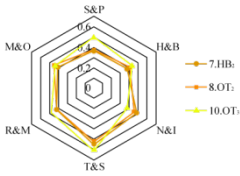
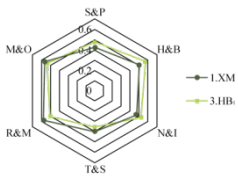
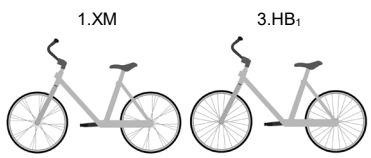
The above results showed:

Figure 5 shows that the visual evaluations of different wheel types of urban bicycle has less extent of difference in trimmed and stable, superior and presentable, and holistic and

balanced. However, the extents of difference were greater in novel and individualized, rhythmic and metrical, and mechanical and ordered. In Figure 8, the Mobye(MB) wheel type has high scores, and the four evaluations of “superior and presentable”, “holistic and balanced”, “trimmed and stable” and “mechanical and ordered” are the highest. In addition, the Bluegogo(BG) wheel type receiving the highest scores in "novel and individualized" and "rhythmic and metrical".

The scores of the visual evaluations of the 10 wheel types of urban bicycle were further applied to the creation of radar charts for the comprehensive comparison of wheel type. By qualitative classification, four groups with relative visual evaluations were summarized. The results are shown in Figure 9: (a) The overall visual image of MB and BG is similar, and the scores are higher in various visual image evaluations. (b) The overall visual images of OF, YH and OT_1 are similar, and the scores are in the second highest group in the visual image evaluations. (c) HB, OT_2 and OT_3 have similar overall visual images, and are more "superior and presentable" and "trimmed and stable". (d) The visual images of XM and HB_1 are similar, and they are more "mechanical and ordered", "rhythmic and metrical", "novel and individualized", and "trimmed and stable". The detailed visual characteristics of the four groups are described in Table 9.

Table 9 The six wheel type groups, respectively, with similar comprehensive visual evaluations.

Group	Radar chart	Wheel Type Species	Visual characteristics
1			The absolute utility values of MB and BG in the six vocabulary groups are in the first group. The number of spokes is small and the width of each spoke is thick.
2			The absolute utility values of OF, YH and OT_1 in the six vocabulary groups are in the second group. The number of spokes is very large, and the layout is uniform and changes regularly.
3			They are biased towards "superior and presentable" and "holistic and balanced". The rims of HB_2 and OT_2 are wider, and the spokes are regularly arranged in an interlaced manner. The OT_3 has a total of four spokes , narrow near the rim.
4			They are biased towards "mechanical and order", "rhythmic and metrical", "novel and individualized" and "holistic and balanced". The number of spokes is large, the layout is uniform, and they are arranged in a regular pattern.

4 Conclusions

This study integrates expert questionnaire survey, factor analysis and fuzzy theory into the research of visual image of wheel types in the urban bicycles. The accuracy of image vocabulary selection affects the authenticity and objectivity of this study. Therefore, this study firstly screens a large number of vocabulary words by means of expert questionnaires, and then reduces the quantity of adjectives through factor analysis. Factor analysis is an objective and effective method for the selection of visual image adjectives. It can quickly reduce the number of adjectives of wheel type, which greatly simplifies the questionnaire between 2D wheel type and visual images. In addition, the semantic variable scale of fuzzy theory is suitable for the measurement and statistics of psychological sensory values. The fuzzy number can obtain accurate absolute utility value after appropriate defuzzification, which is convenient for comparative analysis of the results. However, there are many ways of statistical analysis of psychological sensory values, such as a quantitative- I theory, neural network, grey theory, rough set theory and support vector machine. Therefore, in view of the research of product image, appropriate research methods should be selected to ensure the scientific and rational research purposes.

The research results show that each type of wheel has its own unique visual image, and the different types of wheels have distinguished in trimmed and stable, superior and presentable, and holistic and balanced, while little differ in the novel and individualized, rhythmic and metrical, and mechanical and ordered. In addition, the overall visual imagery of some wheel types has similarities, for example, MB and BG of the first group, XM and HB_1 of the fourth group. Therefore, the overall visual images of some wheel types of urban bicycle in the same group are similar and replaceable in design and application.

The research results can be applied to the design service. Later, more different types of wheels can be collected or designed. Through the research method of this paper, the value of visual evaluations can be further obtained, so that a urban bicycle assisted design system can be established. On the contrary, because there are differences in life styles among different regional groups, the aesthetic needs preferences are also different. If designers accurately grasp the visual image preferences of urban residents, through the established auxiliary design system they can design the appearance of urban bicycle which is more in line with the psychological demands of consumers. In addition, the results of this study are also applicable to the design of urban electric bicycles. As for future research, we can further study the color visual image of the wheels.

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Semantic Evaluation Research on Image of the Packaging for Dishwashing Detergent of the B Corps.

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Social Corporate Responsibility (CSR) is an issue promoted and advocated worldwide in recent years, from which derives B Corps that both make profit from commercial activities and practice CSR. The semantic differentiation method was applied in the survey on the packaging of dishwashing detergent of B Corps. With increasing awareness of the impact of household cleaning products on the environment in recent years, more and more consumers turn to natural and environmentally friendly dishwashing detergent. This study selected the dishwashing detergent products from official websites of B Corps to explore respondents' perception of the visual image of the packaging and the factors possessed by packaging design of B Corps. Semantic evaluation method is adopted for the research on B Corps, including:(1) collecting packaging samples and image words by focus group method; (2) investigating packaging images with semantic evaluation method. The results show that participants' image perception would be affected by three factors: "international and professional", "innovative and attractive" and "authenticity and naturalness". At present, dishwashing detergent packaging of B Corps are mainly designed with the image of "international and professional", which focuses more on conciseness, grace and professionalism but comparatively lacks visual innovation, attraction and diversity. If using more complex visual design or special bottle type, it would relatively lack the design image and concept of reality, nature and sustainability that B Corps intend to convey.

Keywords: B Corps; package; image; semantic evaluation

1 Introduction

Under the industrial movement and the operation of capitalism, many products unfriendly to the environment have been created, and many environmental and social problems have also been caused. Due to the serious environmental pollution problems and the rise of consumers' awareness of environmental protection, governments, non-profit organizations, social enterprises and other organizations have begun to improve the problems. In recent years, there have been emerging social enterprises called B Corps that take into account both profits and fairness. These companies manipulate their own power to make improvement and bring benefits to all participants. On one hand, they can get operating profits for themselves by sell good commodities. On the other hand, with ability to bring benefits both to the environment and human being, they create employment opportunities

and help community transformation. In this way, they achieve “self-interest” by means of “altruistic” activities.

At present, most of the issues discussed are the marketing or operation mode of B Corps, with less emphasis placed on their product packaging design. However, as a good commodity packaging design can add profit to B Corps, packaging image can be regarded as an indispensable element for them. This study intends to deeply understand the current visual image and perceptual impression of B Corps to consumers. There are many brands and product categories of B Corps, which cannot be focalized and easily cause confusion. Dishwashing detergent is a product that can be used by consumers regardless of age and gender. Consumers are concerned about whether their daily cleaning products contain chemical residues that will affect health and cause environmental pollution. It has a close relationship with the sustainability and environmental protection advocated by B Corps and CSR. Therefore, this study selects Home/Personal Care's dishwashing detergent packaging as the survey sample.

The purpose of this study is to analyse the visual image of the packaging image of B Corps, mainly focusing on exploring the visual image and perceptual impression of B Corps dishwashing detergent packaging in the view of the subjects. Meanwhile, it tries to find out the current packaging preferences, and whether the packaging image conforms to the concept of B Corps. It is expected to serve as reference for designers and researchers in the future. The reference purposes of this study are as follows:

Understand consumers' impression of the dishwashing detergent packaging image of B Corps.

Summarize the factors of the dishwashing detergent packaging image of B Corps for reference and use by relevant scholars and designers.

2 Literature Review

Corporate social responsibility (CSR) refers to the company’s promotion of its environmental and social welfare responsibilities (Sen & Bhattacharya, 2001). In recent years, CSR has become one of the key strategies used by companies to promote their own brands, especially those that need to stand out in mature markets. For brands, the appeal of CSR seems particularly attractive. Because more and more brands will use their “good works” or attractive “original stories” to stand out from the competition (Robinson & Wood, 2018). Active corporate social responsibility practices can enhance consumer attention, contribute to the cause of corporate support, and influence the impact of consumer social behaviour (Mantovani, Magalhães, and Negrão, 2017). In recent years, social enterprises have become a noted school of thought. The promotion of CSR has been carried out by government, schools and even in campus education. "Willingness to change" can lead to a better road. If enterprises begin to be willing to invest in social development, safeguard the earth's resources and sustainable development, and strive to be good for people and society, instead of regarding benefits as the primary goal, the world will become happier and more beautiful.

B Corps certification is promoted by the B lab in the United States. It makes customized quantitative assessment on enterprises based on industry category and employee headcounts, which focuses on five aspects, namely corporate governance, employee care,

environmental-friendliness, community care and customer influence. After passing the assessment, the enterprise will be awarded with a B Corps certification, which shall be re-verified every two years[1]. The B Lab developed a B Impact Assessment tool and promotes this systematic (figure 1) to evaluate how a company's operations and business model impact his workers, community, environment, and customers (Honeyman, 2014). B Corps are committed to promoting a global movement for redefinition of a successful enterprise, with the expectation that one day the goal of all corporate competition will no longer be becoming the best enterprise "in the world", but be becoming the best enterprise "to the world". The establishment of a B Corps community will make it easier for the public to distinguish between "good companies" and "marketing-only companies". Moreover, it could promote public welfare company law, which will give business leaders the freedom to balance shareholders' rights and creation of social values. It helps enterprises to evaluate, compare and improve their social and environmental performance by using free benefit impact assessment. By using benefit analysis and Global Impact Investing Rating System (GIIRS) service platform, capital is directed towards impact investment.

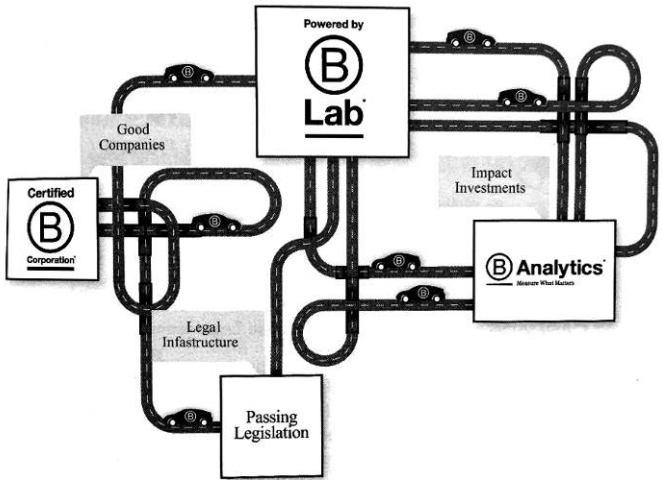

Figure 1. B Corps System.

Source: The B Corps Handbook: How to use Business as a Force for Good. (Honeyman, 2014)

The B Corps model has a social and environmental mission and purpose. The main goal is to create positive social impacts for stakeholders, rather than maximizing profits. The B Corps internalize the social and natural environment of their own businesses and try to participate in institutions. B Corps provide thought leadership around sustainable development, and drive broader change (Stubbs, 2017). At present, there are more than 2500 B Corps in the world, covering 70 industries and 64 countries, among which 27 are located in Taiwan[1]. B Corps are good not only to the public but also to themselves. They can balance their efforts to make the world a better place with their own profit-making. They can work with enterprises with common goals, attract talents, and enhance the centripetal force of employees. In addition, they can leave a positive impression of their enterprise brand on consumers. Finally, a global group activity will be formed to strive for a better society. B Corps will grow stronger in the future.

[1] B Corps official website, Available at: http://blab.tw/what-is-b-corp/ (last visited Dec. 2, 2018).

The image of brand goods ultimately needs to be conveyed through the product packaging. Packaging design helps to establish sensory links between products and consumers. Products can bring personal contact and hope to the public, and even enhance public life. When people are surrounded by beautifully packaged products, they not only have a good feeling, but also have deeper impression of the products. Packaging is a common element of modern consumption, which provides a wide range of functions and consumer interests. The function of packaging is the most important in the consumer market. If the packaging is designed to be durable and unique, but without after using the packaging, it has no other function, which increases the environmental burden, leads to the warming of the earth and consumes a lot of energy and resources (Steenis, van Herpen, van der Lans, Lighthart & van Trijp, 2017). B Corps must be able to return to society through income, so socially responsible brands or packaging will be a bridge to communicate with consumers, and the benefits of brand or packaging will be the reason for B Corps to give back to society.

What should the image of a B Corps convey to consumers? The product identity or image is formed from people's cognition of product. Through its own design in such aspects as colour, line, texture and structure, as well as the connotative meaning endowed by the environmental culture, the product forms the language it wants to convey. Basically, the linguistic image conveyed by these products is still considered from the point of view of human needs. Designer aims at the needs, feelings and ideas of human beings to design the linguistic image that shall be convey through the product shape in their minds (Chuang, & Kao, 1997). If the image that a product shall have is not judged only from the functional aspect, product image is a psychological feature. People present something in their minds through association or imagination. Although it is invisible in reality, they still think of similar pictures in their minds (Lin, 2009).

Based on the changes and evolution of designs of the shape, colour, material, structure and graphic image of commodity packaging, we can see the trend of the current social issues. Design can reflect the message of the product to consumers, from which consumers can know the brand spirit that its brand wants to convey. This study selects the packaging design of Dish Wash of B Corps as the research object. Through research and analysis about the packaging design of dishwashing detergent of B Corps, it tries to explore how design behaviour can solve the current social problems in the world, which is the most important issue to be faced outside the basic solution. From design competitions held at home and abroad in recent years, we can see the current design trend in the world. Papanek (2013) believes that before engaging in design work, designers must have their own social and moral judgment standards, that is, whether their design is helpful to the society. Designers must have empathy and shall not ignore social problems or waste resources to meet their own design expression. Only in this way can they produce a design that is really needed by the world and society.

3 Methods

3.1 Methods and processed

The purpose of this study is to explore people's perception of the visual images of the dishwashing detergent packaging in B Corp, which needs to be investigated objectively. Therefore, most quantitative visual opinions are adopted in this study. The research methods are focus group method and semantic difference questionnaire method. Firstly, we searched

for the dishwashing detergent packaging in Home/Personal Care category of B Corp, and used focus group method to select 10 different packaging samples. Meanwhile, we also collected packaging-related image words, which were converted into adjectives with KJ method by professionals with design background. At the third stage, we conducted image questionnaire survey by distributing image questionnaires through the network. 171 net users of different age groups from design and non-design-related departments were investigated by snowball means. After the questionnaires were collected, statistical analysis was carried out by SPSS.

3.2 B Corps packaging samples screening

In this study, packaging samples were collected from the official websites of B Corp[2]. The products identified are those that are used by most age groups regardless of gender and with packaging related to nature and environmental protection. Therefore, the researcher selected the dishwashing detergent products from the industry category Home/Personal Care. The search time of packaging brands and samples was before November 10, 2018. There were 129 enterprises in the Home/Personal Care classification, from which the researcher searched for all the dishwashing detergent products and obtained 15 samples. A focus group including 5 professionals with design background selected largely different packaging designs from these samples. Finally, 10 samples were selected as the tested samples.

Table 1 B Corp packaging sample.

Sample No. /Brand	01 method	02 earthy	03 little innoscents	04 baleco	05 cha tzu tang
Sample					
Sample No. /Brand	06 BoulderClean	07 dephis eco	08 EO	09 made of	10 Dr. bronner's
Sample					

3.3 Selection of adjective vocabulary

For the sematic evaluation survey to understand the image of packaging design for the dishwashing detergent 's, we need to collect enough image words, establish adjective vocabulary data, and set up appropriate adjective vocabulary. After collecting the image vocabulary of relevant documents and books about packaging design and eliminating repetitive adjectives, the researcher obtained a total of 150 words, which were then

[2] B Corps official website, Home / Personal Care, https://bcorporation.net/directory?search=&industry=Home%20%26%20Personal%20Care&country=&state=&city=&page=4 (last visited Nov. 11, 2018).

classified by five professionals with design background and sorted and revised with KJ method. Finally, a total of 12 groups of image vocabulary were selected.

Table 2 Packaging adjective vocabulary.

conservative–innovative	dull–attractive	artificial–nature
rough–exquisite	affordable–expensive	abstract–real
ordinary–unique	plain–colourful	indifferent–cordial
dirty–clean	amateur–professional	local–international

3.4 The questionnaire

The questionnaire is divided into two parts. The first part is the basic information about the respondents, including the gender, age, whether the respondents have design background, monthly salary and education background. The second part is to design a semantics analysis scale for the matched packaging image words to investigate the packaging image of 10 B Corps. Each tested packaging has 12 groups of vocabulary, and each vocabulary is composed of two relative adjectives at the ends of the scale. The scale has grades from 1 to 7 from left to right. Taking "conservative-innovative" as an example, 1 score represents “very conservative”, while 7 scores represent “very innovative”.

Figure 2. Semantics Scale

In this stage, the questionnaire survey method is used to fill in and answer the questions on the internet. The 10 B Corp sorted out by Table 1 are: 01 Method, 02 Earthy, 03 Little Innoscents, 04 Baleco, 05 Cha Tzu tang, 06 Boulder Clean, 07 Dephis Eco, 08 EO, 09 Made Of and 10 Dr. Bronner's, among which the dishwashing detergent packaging products is used as the sample to understand the audience's perception and feeling of the sample. The on-line questionnaire survey was conducted from November 27 to December 7, 2018 by convenience sampling, with 171 respondents receiving the survey, including 65 males (37.4%) and 106 females (62.6%); the majority of respondents are aged between 26 and 35 (51.5%) and are with educational level of universities (56.7%) and research institutes (33.3%).

3.5 Analysis

After the questionnaires were collected and coded, SPPS statistical software was used to make reliability analysis, descriptive statistics, average value, standard deviation, factor points, factor analysis and cluster analysis. Through data analysis, this research investigated the packaging image of the dishwashing detergent of B Corps and summarized the factors of packaging image.

4 Results

4.1 B Corps Packaging Image Analysis Results

Preliminary reliability analysis was carried out on the test results with Alpha value model. The Cronbach Alpha value is 0.949 based on the analysis, which shows that this study has acceptable reliability.

Table 3 Reliability analysis.

Cronbach's Alpha	Cronbach's Alpha Base on Standardized Items	N of Items
0.949	0.949	120

In Table 4 descriptive statistics, we can see that the lowest average score falls to the item "plain/colourful" (M=3.67), indicating that respondents don't have strong feelings about this image item, while the highest average score falls to the item "dirty/clean" (M=5.88), representing that the average samples give a clean image feeling. There is a high standard deviation in three adjective groups, namely conservative/innovative, affordable/expensive, ordinary/unique, showing big differences in the feelings of these three image groups.

Table 4 Descriptive statistics.

	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
conservative–innovative	10	2.4561	5.5380	4.022790	.8514142
rough–exquisite	10	2.4094	4.9766	4.162590	.7466761
ordinary–unique	10	2.4094	5.5205	4.053810	.8192503
dirty–clean	10	4.0643	5.8830	5.039180	.5302648
dull–attractive	10	2.4620	5.2515	4.129830	.7631674
affordable–expensive	10	2.3158	4.9240	3.936840	.8409307
plain–colourful	10	2.8129	4.7251	3.673110	.7047393
amateur–professional	10	3.3450	5.1170	4.451470	.5450802
artificial–nature	10	2.5556	4.7368	3.986560	.7457758
abstract–real	10	3.5439	4.9591	4.240940	.4077156
indifferent–cordial	10	3.1579	4.6784	4.152050	.4932730
local–international	10	3.4444	5.1637	4.402910	.5310323
Valid N (listwise)	10				

Table 5 shows the design characteristics of the dishwashing detergent packaging image of the tested samples. The average data showed high or low image adjectives, indicating that the sample had the image. According to Table 4, Sample 01 had the most "clean" image, Sample 02 had the most "natural", "real" and "cordial" image, Sample 03 had the most "exquisite" image, and Sample 04 had the most "expensive" image. The images of Sample 05 are the most "innovative", "unique", "professional" and "attractive". Sample 07 is the most "conservative", "rough", "ordinary", "dull", "affordable", "plain" and "artificial" and the image of Sample 08 is "colourful", while other samples don't have prominent images. The average scores of packaging images are shown in the following list:

Table 5 Average score of packaging images.

Sample No. / Adjective vocabulary SD	01	02	03	04	05	06	07	08	09	10
conservative–innovative	4.06	3.41	4.02	4.46	5.53	4.25	2.45	4.80	3.90	3.29
rough–exquisite	4.67	4.27	4.97	4.70	4.49	3.63	2.40	4.60	3.98	3.85
ordinary–unique	3.91	3.67	4.05	4.69	5.52	4.02	2.40	4.68	3.97	3.59
dirty–clean	5.88	5.33	5.46	5.57	4.67	4.91	4.06	4.98	4.75	4.74
dull–attractive	4.23	4.03	4.51	4.67	5.25	3.98	2.46	4.63	4.04	3.46

affordable–expensive	3.62	3.84	4.70	4.92	4.87	3.15	2.31	4.49	3.42	4.00
plain–colourful	3.01	3.56	3.22	3.10	4.69	4.39	2.81	4.72	3.78	3.39
amateur–professional	4.56	4.26	4.87	4.94	5.11	3.97	3.34	4.87	4.09	4.44
artificial–nature	4.66	4.73	4.45	4.70	4.19	3.07	2.55	3.42	3.99	4.06
abstract–real	4.66	4.95	4.35	4.45	4.01	3.88	3.97	3.54	4.32	4.22
indifferent–cordial	4.57	4.67	4.48	3.95	4.29	4.39	3.15	3.84	4.52	3.61
local–international	4.57	4.21	4.90	5.16	4.13	4.07	3.44	5.01	4.00	4.50

4.2 Factor analysis of B Corps package image

Based on 171 participants' perception of 10 Dish Wash packaging samples of B Corps and 12 groups of semantic adjectives, the principal component method was used to extract the factors, and then the maximum variation method was used to make the rotation analysis. The following three data were obtained: (1) the total variation scale of semantic factor analysis (table 6); (2) the factor analysis load scale (table 7); (3) the factor acquisition point table (table 8).

Using Kaiser Criteria to retain the factors with eigenvalues greater than 1, three common factors were obtained. The cumulative variation was 93.5%, representing 90% of the total variation. Referring to Osgood's three main factors of semantic space proposed in 1969: evaluation, potency and activity, the first factor contained four image adjectives: local-international, cheap-expensive, amateur - professional, rugged - refined, named as “international professional factor”, eigenvalue = 7.199, explanatory variance = 59.9%.

The second factor includes four image adjectives: plain-colourful, conservative-innovative, ordinary-unique, dull-attractive, image adjectives that tend to describe psychological feelings, with personal perception, feelings, personal preferences and preferences, mainly expressing the respondents’ visual impression of the packaging, which are all related to the attraction degree of the packaging of B Corps, named as “innovative and attractive factor”, eigenvalue=2.864 and explanatory variance=23.8%.

The third factor also contains four image adjectives: abstract-real, indifferent-cordial, artificial-natural, dirty-clean, with tendency toward product power and functional description. The main purpose of the third factor is to express the different visual perceptions of product functions described by the respondents, which are all related to the cordial and real feelings of packaging of B Corps. Therefore, it is named "cordial natural factor". The eigenvalue was 1.159 and the explanatory variance was 9.6%.

Table 6 Total variance Explained.

com ponent	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumul-ative %
1	7.199	59.994	59.994	7.199	59.994	59.994	4.609	38.410	38.410
2	2.864	23.863	83.857	2.864	23.863	83.857	3.576	29.801	68.211
3	1.159	9.658	93.515	1.159	9.658	93.515	3.037	25.305	93.515
4	.460	3.836	97.351						

5	.170	1.419	98.770						
6	.084	.699	99.469						
7	.036	.302	99.770						
8	.020	.167	99.937						
9	.008	.063	100.000						
10	3.600E-16	3.000E-15	100.000						
11	-6.353E-17	-5.294E-16	100.000						
12	-3.817E-16	-3.181E-15	100.000						

Table 7 Total variance Explained.

Factor / Adjective vocabulary	component		
	Factor 1	Factor 2	Factor 3
local–international	.941	.047	.105
affordable–expensive	.869	.389	.135
amateur–professional	.859	.450	.168
rough–exquisite	.777	.357	.484
plain–colourful	-.032	.928	-.232
conservative–innovative	.479	.851	.054
ordinary–unique	.562	.795	.102
dull–attractive	.614	.717	.306
abstract–real	.055	-.409	.873
indifferent–cordial	.019	.438	.868
artificial–nature	.584	-.012	.765
dirty–clean	.599	-.048	.696

The results of factor analysis in this study show that the evaluation of the dishwashing detergent packaging of B Corps can be made from three factors: international professional, “innovative and attractive” and cordial natural factors, which be assisted with cluster analysis in the next stage to examine the correlation of samples from the cluster way of packaging samples, and the appropriateness of image definition of packaging factors in B Corps in order increase the objectivity of this study.

Table 8 Factor Score.

Factor / Sample	Factor 1 international professional	Factor 2 innovative and attractive	Factor 3 cordial natural
01 method	0.20954	-0.50142	1.26963
02 earthy	-0.56349	-0.28881	1.55140
03 little innoscents	0.93244	-0.34823	0.45409
04 baleco	1.58735	-0.56788	0.00936
05 cha tzu tang	0.09774	1.87237	-0.17812
06 BoulderClean	-1.16322	0.91859	-0.17045
07 dephis eco	-1.41314	-1.44101	-1.43108
08 EO	0.88913	0.87679	-1.36671
09 made of	-0.97126	0.40731	0.55892
10 Dr. bronner’s	0.39491	-0.92772	-0.69703

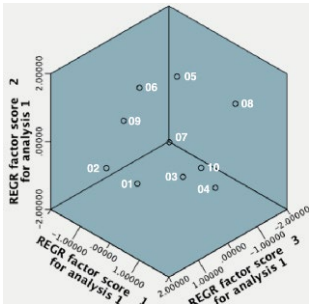

Figure 3. Factors scatter plot (3 facotrs)

4.3 Cluster analysis of B Corps package model

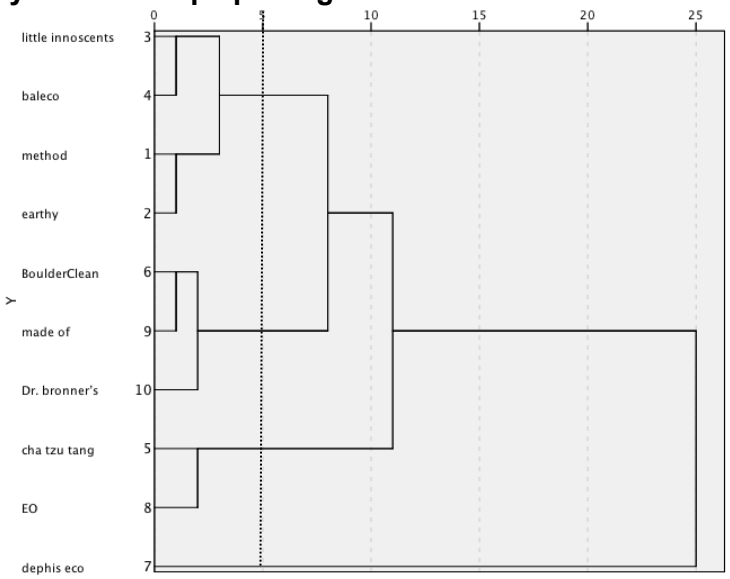

Figure 4. Cluster analysis of B Corps package model

Table 9 B Corps package cluster.

First Cluster	03 little innoscents 	04 baleco 	01 method 	02 earthy 
Second Cluster	06 BoulderClean 	09 made of 	10 Dr. bronner's 	
Third Cluster	05 cha tzu tang 	08 EO 		
Fourth Cluster	07 dephis eco 			

Cluster analysis is based on objective clustering of the common attributes of the samples. There are small differences within the same cluster but large differences among the groups. In this study, the tested samples are clustered on average. With Ward's clustering method of hierarchical cluster analysis, the interval measurement of the square of the distance between Euclid lines was used to cluster the tested samples and form a tree structure of clusters. Figure 4 is a tree structure of the cluster analysis of B Corps packaging, including four clusters. The analysis is as follows:

Samples 3 and 4 in Cluster 1 tend to be highly “international and professional”, while Samples 1 and 2 are “cordial and natural”. All the 4 packaging samples give mild and lively colour feelings and their graphic designs give natural and intimate feelings, so they are defined as “real and natural cluster”. After a comparison in the factor point table of Cluster 2, it can be known that Sample 6 is highly innovative and attractive, Sample 9 has high cordial and natural factor, while Sample 10 is highly professional and international. All of the samples obtain points in respective factor items. Three packaging samples have a preference for cold colour and use informative graphics and text as layout materials in graphic design, presenting a clear visual style, which are therefore defined as Rational and Pure Cluster. Samples 5 and 8 of Cluster 3 obtained low points in “cordial and natural” factor, but higher points in “innovative attractiveness” and “international and professional”. These two packaging samples have such features as unique colour, vivid graphic design techniques and concise information, and therefore are defined as “international and innovative cluster”. The fourth Cluster is Sample 7, which has a negative point under three factors and nearly the same points under three factors. From the analysis about the packaging sample, it can be known that Sample 7 is more conservative in the choice of packaging materials, more straightforward and flat in graphic layout design, and doesn’t have special memory points, and so it is defined as “traditional and flat cluster”.

5 Discussion

In this study, the dishwashing detergent packaging design of B Corps was taken as the theme. After investigation and analysis, three factors affecting packaging image were obtained by collocation factor analysis, namely “international and professional”, “innovative and attractive” and “cordial and natural”. From cluster analysis of packaging samples, the homogeneous packaging was classified into the same type, and four different types of clusters were obtained: real and natural group, rational and pure group, international innovation group and traditional and plain group. In summary, there are three reasons: (1) approximation of packaging image; (2) expression of design techniques; (3) conformity of the product requirements.

The three reasons concluded in this study are:

(1) Approximation of packaging image: Whether from the perspective of factor composition or cluster analysis, in terms of product packaging image, visual perception of bottle shape and other packaging design, product packaging with similar design techniques will naturally be categorized as a group with the same or similar image, that is to say, it is quite easy for the respondents to classify product packaging with common or similar design sense.

(2) Forms of expression of design techniques: Based on the above, art design techniques are the most critical way to express product images. As an image classification method, design techniques transform the image value transmitted by B Corps and the clean product

images into visual symbols. The artistic design forms chosen by designers will affect the final image of packaging.

(3) Conformity of the product requirements: From the factor acquisition point and cluster analysis, it can be seen that it is easier to express the real and natural product image, followed by the international and pure images, while the rational and innovative images are more difficult to express.

Therefore, the degree of conformity between product requirements and B Corps will be changed by the design technique in the presentation of tonality and the expressio Packaging Sample 7 is an independent cluster; the respondents tend to have conservative and cheap product images, and the visual perception expressed by packaging design cannot get too much resonance of the respondents in the packaging materials and aesthetic level. Although it is unique among the sample cluster, after comparing it with the research sample data analysis and factor points, we can know that this presentation method is not an appropriate presentation of packaging design, as it cannot reflect the visual image of B Corps products. On the whole, through the respondents' conclusions on the image of B Corps packaging model, the results of factor analysis and cluster analysis can complement and support each other, thus deducing the appropriate visual image of B Corps product packaging.

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Study on the Model of the Elderly's Service Needs of Smart Home: Construction and Application

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Abstract: With the increasing number of the elderly population, many countries in the world are gradually entering a more and more serious aging society. According to the survey, 90% of people will choose to live at home when they become older. However, with the physical function and social function decline of the elderly, the independence and safety of the regular home-based life cannot be guaranteed. The smart home care system equipped with modern Internet technology can use systematic and information-based technology to help the elderly to achieve a more independent and safe retirement. The smart home is an emerging industry. At present, there is not much research on the elderly population in this field, and it mainly focuses on the technical field, a few kinds of research on demand and service. There are many problems in smart home products and services on the existing market, such as functional redundancy, technology is not mature enough, or does not really solve the pain points of the elderly, so the market penetration is not high until now. However, there is no doubt that the popularity of smart homes is an inevitable trend, and it has become one of the hotspots of current research, especially in the field of home care, which has great potential and will help the society and the government solve numerous aging problems. Based on the analysis of the literature, this paper puts forward an elderly service needs model based on Maslow's hierarchy of needs, aims to provide more high-quality smart home services for the elderly. Moreover, from the perspective of service design, it discusses the development stage of the smart home and the mechanism of service satisfaction of the elderly. The research can provide a good reference for the products and services development for the elderly from an user-centered aspect in the smart home field.

Keywords: aging society; the elderly; service; needs; smart home

1 Introduction

The 21st century is an era of aging population. The pension way of the elderly mainly includes three types: social pension, institutional pension, and home pension. The survey shows that 90% of the elderly will choose to live at home after retiring[1].However, with the decline of both physical and social function of the elderly, the independence and safety of the regular home-based life cannot be guaranteed. Smart home, which is equipped with systematic and modern Internet technology, can help the elderly to live an independent and safe aging life.[2].At the same time, smart products have a strong penetration, which has long-term effects on alleviating the shortage of social labor and reducing the economic

burden of social pension. But, the majority of contemporary smart home researches focus on the technical field, a very few researches on needs and service [3], however, there are many problems in the smart home products and services on the existing market, such as functional redundancy, immature technology, or does not provide service to solve the real pain points of the elderly, so the market penetration is not high[4]. In order to fully explore new opportunities for the development of smart home industry in an aging society, we need to analyze these questions in depth: What are the service needs of the elderly? What are the characteristics and contents of these needs? Which kinds of products can meet these needs? What are the development phases of a smart home? How to satisfy the elderly while providing smart home services? Our research will explore the questions above. This paper is divided into six parts. The second part of the paper is a brief literature review, the third part introduces the research method, and the fourth part constructs a service needs model of the elderly based on Maslow's hierarchy of needs. The fifth part discusses the application of service needs model in different development stages of smart home and the mechanism of service satisfaction of the elderly. The sixth part summarizes the whole thesis and looks forward to the follow-up research.

2 Literature review

At present, the research on the elderly mainly studies in three perspectives, physiology, psychology and sociology. The physiological and psychological perspectives mainly study the old age physiological and psychological problems. The sociology mainly focuses on the social behavior problems of the aging [5]. Some scholars have used empirical research methods to investigate different types of needs of elderly people and their satisfaction with life [6][7]. Some researchers have specifically discussed the issue of community care and medical security for the elderly [8]. In addition, some scholars have studied the behavioral characteristics of the elderly, and based on these characteristics, proposed the services that should be provided to the elderly [9].

With regard to smart home, the literature review has been done over major multiple scholarly databases including Scopus, IEEE Xplore, ACM Digital Library, SpringerLink, ScienceDirect, PubMed, and Web of Science. Depending upon the intended purpose and actual usage scenario, the smart home is segmented into five different dimensions for the elderly as health monitoring, environment monitoring, providing companionship, social communication, and recreation and entertainment [10]. The outcome of literature review of smart home for the elderly clearly indicates that a lot of work has been done towards their well-being. The majority of them are experimental projects that follow a technology centric approach. However, in order to promote and provide better smart home services, and improve the acceptance and market share of smart home products and services for older people. it is very important to analyze their services needs, from a human-centered aspect. However, there is a lack of theoretical approach and systematic model in this aspect of aging research.

3 Research method

This paper mainly uses the combination of deductive method and literature analysis method to conduct research. Deduction is a logical method of deriving individual conclusions and new information from universal theory or general affairs [11]. We can interpret the needs of the elderly with reference to the general needs of human beings, and then interpret the elderly service needs toward smart home. Maslow's hierarchy of needs is one of the important theories of behavioral science, was proposed by American psychologist Abraham

Maslow in 1943 in the paper "A Theory of Human Motivation"[12]. It argues that human needs have a process of development from low to high, and divides human needs into five levels, namely, the physiological needs, the safety needs, the love and belonging needs, the esteem needs and the self-actualization needs, which is a general law that conforms to the needs of human development with a wide range of applications.

4 The elderly service needs model

This paper uses literature analysis methods to extract and generalize the needs of the elderly, use the Scopus, IEEE Xplore, ACM Digital Library, SpringerLink, ScienceDirect, PubMed, and Web of Science database to search, set the search terms as “titles”, search terms “old age” and “needs”, and “ the elderly” and “demands”, accurately searched the data from 1980 to 2018; Due to limited energy, we have studied 40 articles, as well as the recommended topics “Elderly Needs” and "Analysis of the needs of the elderly", 25 documents with full texts retrieved by subject search. In the process of reading these 65 literatures, we extracted keywords about the needs of the elderly, such as: diet, clothing, emotions, nursing, etc., and divided these keywords into five categories according to Maslow’s hierarchical needs theory. They are physiological, safety, emotional, esteem, and self-actualization needs. Table 1 summarizes the needs keywords with higher frequency and the cumulative frequency of each need level appearing in the literature.

Table 1 The elderly needs analysis

	Cumulative frequency	Frequently occurring keywords	Inductive demand
Physiological needs	54	Longevity, material life, diet, clothing, health products, convenient transportation, elderly apartments, elderly communities, disability, nursing services, long-term care, daily life care, escort center, living alone, reducing children Burden, pension in different places, emergency response, etc.	Clothing, food, housing, transportation, healthcare
Safety needs	47	Physical and mental health, medical treatment, medical conditions, health care products, medical health knowledge, medical expenses, medical security, disposable income, economic security, poverty risk, healthcare products quality, legal rights services, children abuse parents, old-age care institutions , safety protection facilities, government assistance, collective assistance, social security, welfare policies, etc.	Life safety, property safety, pension security, social security
Love and belonging needs	40	Family warmth, love, psychological and emotional crisis, loneliness, spiritual comfort, spiritual support, mental health, social activities, religious beliefs, senior clubs, old-age leisure, online chat, senior TV programs, community culture, elderly toys, seniors tour groups, entertainment activities, spiritual consumption, etc.	Family, friendship, love, community, faith
Esteem needs	7	Face-loving, self-respect, attitudes, body, clothing, knowledge, self-cultivation, family status, self-evaluation of health, "healthy old people" selection, social discrimination for the elderly, respect for the elderly, etc.	Self-affirmation, family/group/social status
Self-actualization needs	18	Self-improvement, find work, achievements, senior university, specialties, advance with the times, knowledge contest, the elderly enterprise, social contribution, play the heat, re-employment, etc.	Master new knowledge and create value

From the selected keywords, we can see that the elderly have the same physiological needs as the average person, but because of the physiological functions decline, such as vision, hearing, language ability, positioning ability, memory ability, the aging population has other relatively prominent needs[13]. Referring to the Maslow's hierarchy of needs, the elderly needs model is analyzed and summarized, see Table 1.

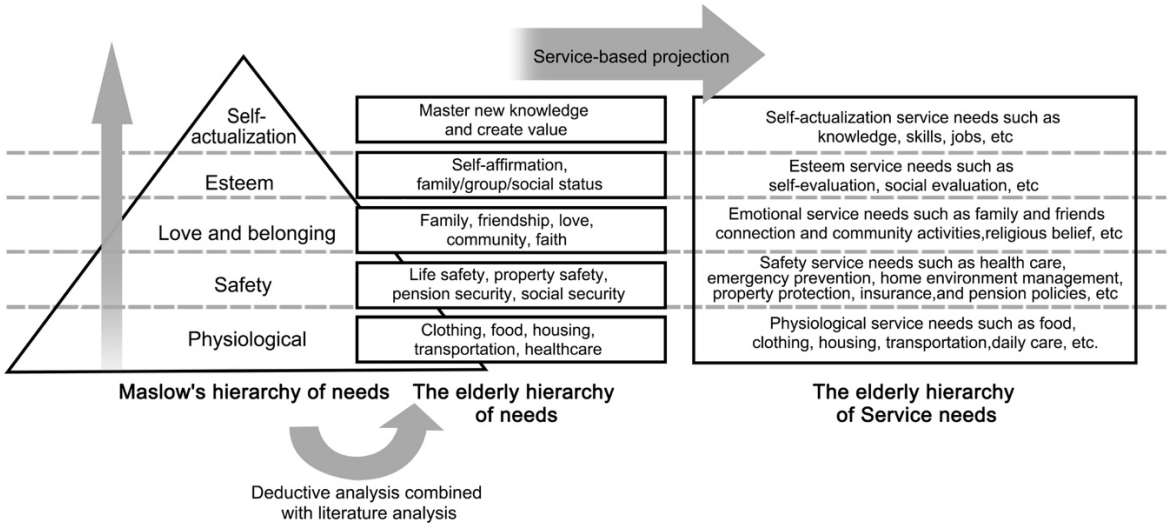

Figure 1. the analysis process of the elderly service needs model

Based on the previous hierarchical model of the elderly needs, we project the elderly service needs model from the user-centered perspective. The service needs of the seniors at each level in Figure 1 are briefly described below.

4.1 Physiological service needs such as food, clothing, housing, transportation, daily care, etc.

In addition to the needs of the general human physiological needs such as clothing, food, housing, transportation, etc., the physiological needs of the elderly should also include the healthcare and daily care, due to their certain mobility disorders and cognitive impairments. In the smart home environment, all kinds of products should follow the cognitive and behavioral patterns of the elderly, and in the principle of easy to use and ensuring safety, maximize the help of the elderly to overcome their physical and psychological barriers and help them to enjoy independent and safe life and improve the quality of life for the elderly[14].

4.2 Safety service needs such as healthcare, emergency prevention, home environment management, property protection, insurance, pension policies, etc.

For the elderly, security needs are embodied in four aspects: life safety, property security, pension security and social security. Among them, the demand for life safety is embodied in the demand for the health and medical security system; the demand for property security is the protection of property at home and the prevention of fraud; the pension security guarantees the elderly from the system and policy; the social security refers to the security guarantees formed by the society for the elderly, such as the public facilities that fully consider the special needs of the elderly. With the increase of age, and physiological and psychological functions decline, the demand for medical and health services of older people is more abundant than that of young people [15]. Moreover, the elderly have limited

economic income and weak self-protection ability, they need to obtain policy protection information and understand the legal information to protect their rights and interests [16].

4.3 Emotional service needs such as family and friends' connection, community activities, religious belief, etc.

For the average person, the emotional needs include two aspects, one is the need of love, including the need of friendship, family and companion; the second is the need of belonging, that is, to become a member of the group, and care for each other. In fact, the elderly need more emotional care than the average person [17]. Older people need not only information from their children, but also from their friends. Similarly, in order to give the elderly a sense of belonging, they also need information about the social groups and religious beliefs they care about, such as social news and community, and information on activities of the elderly groups.

4.4 Esteem service needs such as self-evaluation, social evaluation, etc

The needs of the average person to be respected can be divided into internal respect and external respect [18][19]. Internal respect refers to the individual's need for confidence and independence in their own strength; external respect refers to the individual's desire for external respect, trust and high evaluation. Combined with the analysis of the characteristics of the elderly, their respected needs are embodied in four aspects: the self-affirmation, the status in the family, the status in the groups, and the general social status. At the service demand level, internal respect and external respect requires tools and information that separately rely on self-evaluation and social evaluation.

4.5 Self-actualization service needs such as knowledge skills and jobs

This is the highest level of need for the elderly. Older people need to master new skills and learn new knowledge, as well as corresponding jobs, in realizing the ideals of their lifelong dreams or using their personal strengths to create value for the society. The knowledge and experience of the elderly is a valuable social asset. The society should integrate a variety of resources to provide more opportunities to the elderly with job needs, so that the elderly with work ability can find space to play their own heat [20].

5 The application of service needs model in smart home

The development of smart homes for the elderly can be divided into three phases, which are mutually progressive, as shown in Figure 2. At the same time, the five levels of the elderly needs are at all phases of the development of smart homes. The higher the level of need, the higher the requirements for smart home technology, products and service systems. Only by taking users as the center and using user needs as the foundation of technology and system development can we develop suitable smart home products and services for the elderly.

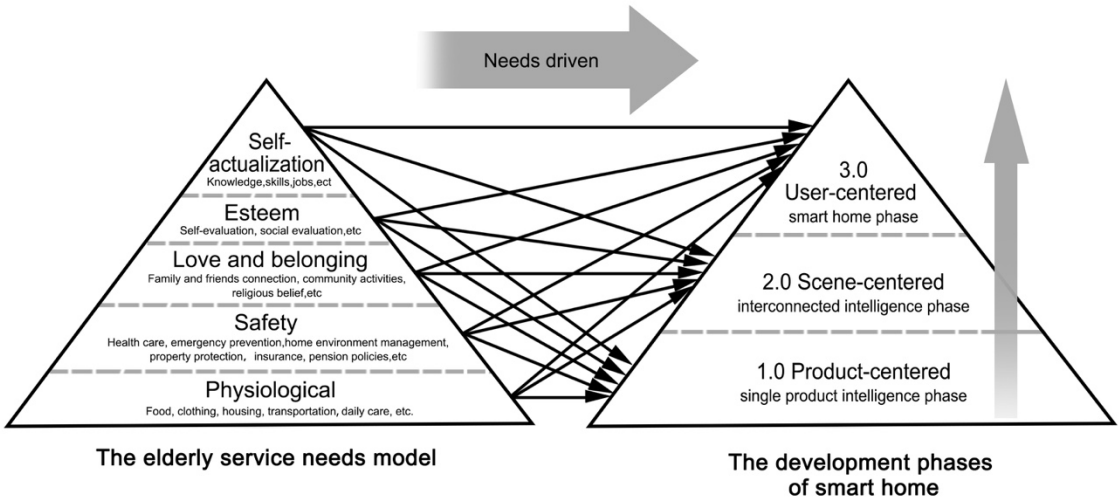

Figure 2.The elderly service needs model and development phases of smart home

5.1 The development phases of smart home

At all stages of the development of smart homes, considering the physical and psychological characteristics of the elderly population and their behaviour model, living habits, etc., developers and enterprises should focus on every service touchpoints during the service delivering process, including physical touchpoints(hardware), digital touchpoints(software), interpersonal touchpoints (humanware) [21], to improve the service experience of smart homes for the elderly. Figure 3 summarizes the features and contents of each stage of the smart home.

5.1.1 Product-centered phase

The networking and intelligentization of a single product, may include smart home appliances, furnitures, wearable devices, medical testing devices, healthcare devices, entertainment devices, transportation devices, gateway devices, social devices, environment adjustment devices, lighting systems, security systems, smart control systems, etc;

5.1.2 Scene-centered phase

This phase is the interconnection between smart home devices, to realize systematic control and intelligent adjustment, according to the life scene requirements of the elderly, the application scenarios may include sleeping mode, wake-up mode, leaving home mode, eating mode, working mode, learning mode, security mode, guard mode, bathing mode, exercise mode, theater mode, entertainment mode, party mode, birthday mode, romantic mode, family interaction mode, festival celebration mode, etc ;

5.1.3 Use-centered phase

This phase provides differentiated smart home services to specific user needs, while the home system can conduct self-learning, with the ability to collect, analyse data and make decisions. It can sense and observe the physiological and emotional situation of the elderly, judge their needs, give active services provision, the main features of this phase are service module selection, individual customization, system self-learning, automatic adjustment, etc

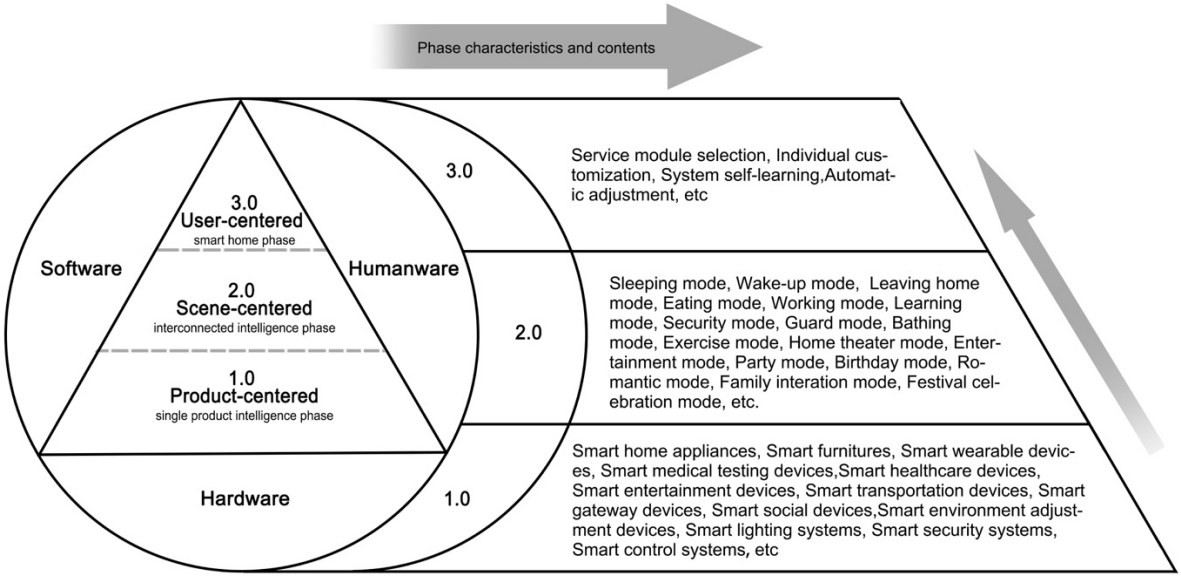

Figure 3.Smart home phases characteristics and contents

5.2 The mechanism model to improve life satisfaction of the elderly

We give the conceptual model of the action mechanism of the smart home to improve the satisfaction of the elderly, as shown in Figure 4. Figure 4 includes three constructs, where the independent variable is suitable smart home services and uses the five evaluation indicators from Servqual (Service quality) Model, which are tangibles. reliability, responsiveness, assurance, and empathy [22]. The intermediate variable is service satisfaction for the elderly with five different levels of service needs; The dependent variable is the elderly satisfaction, include both self and social aspects.

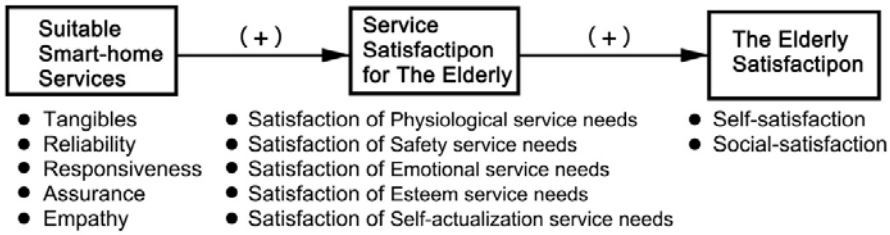

Figure 4.The mechanism model to improve life satisfaction of the elderly

6 Conclusion

The contemporary smart home industry not only needs technical development research, but also needs a user-centered perspective to explore the user's dominant and hidden needs, to design and develop smart home services and products that meet the needs of the elderly. Based on the interpretation of Maslow's hierarchy of needs, this paper proposes a theoretical model of service needs for the elderly. Simultaneously, the application of service needs model in the field of smart home is analyzed, and the mechanism of service satisfaction of the elderly is proposed. This paper only makes a preliminary theoretical study on the service needs of the elderly and their interaction with the smart home. In the future research, we will use the questionnaire survey and interviews to test the elderly service needs model and the satisfaction mechanism model by empirical data.

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Styling of Refrigerator Lighting by Altering its Chromaticity and Placement

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This study investigates how to style refrigerator lighting through varying its chromaticity and placement toward desired user emotion. Eighteen lighting stimuli were produced by combining six chromaticity levels and three placement levels. A total of 177 Korean women in various age group participated and assessed the lighting stimuli using ten affective scales. Conjoint analysis found the possibility of clustering ten affective scales. The correlation analysis found the four aspects which describe the characteristics of lighting styles: performance, aesthetics, visual comfort, and overall satisfaction. To be specific, cool white lighting placed in front side appealed the well-functioning. Further, when the shelves were lit in pink white, the refrigerator interior was evaluated to be the most attractive and stylish. Shelf lighting in bluish-green white would be optimal when visual comfort matters more. We expect that this study could be a good stepping stone of expanding the empirical studies in diverse product categories, so that the designers may choose and place lighting properties more successfully.

Keywords: refrigerator lighting, design style, chromaticity, placement

1 Introduction

The range of materials have been expanded in everyday and the material development opens the diverse choice of designers in their design process. The material evolves to have flexibility and intelligence which is hard to expect in existing static materials such as ordinary plastic, concrete, or wood. As new classes of advanced materials are emerging, influenced by computing. The systematic classification of new materials have been made. According to Parisi et al. (2018), the new kinds of materials is called as ICS, an acronym for Interactive, Connected, and Smart. The tentative map of ICS materials was defined and classified material with three categories: inactive materials, reactive materials, and proactive materials. The traditional materials are the inactive materials which behaves in a passive way. Reactive materials includes smart materials like thermo-chromic inks. Proactive materials are the programmable materials and these allow designers to make creative product design ideas. The emergence of new and advanced material let designers to have expansion of creative idea (Bergström et al., 2010). Hence, the prototyping tools have been developed to support

designers to elaborate those new types of materials in their design process (Vallgårda, Boer, Tsaknaki, & Svanaes, 2016).

In this circumstance, light has been considered as a critical design material for the product design (Brownell, 2017). It is not hard to find products employing light as a key design elements (e.g., clothing (Harold, 2006), bicycle wheels (Chen, Ciou, Jhang, & Liang, 2016)) where light has not been applied before. In addition, active commercial movements of using light as a design element can be identified mainly in objects that have interior space with a lighting system. For example, the Mercedes-Benz S-class series introduced six types of light programs: freshness, warmth, vitality, joy, comfort, and a three-mode option. To offer emotional driving experiences, Kia automobiles collaborated with Pantone color and proposed seven kinds of mood lighting for Kia's K9 passenger car. Ambient lighting evokes the positive effects to passengers' well-being while on the road (Grimm, 2003; van Huysduynen, Terken, Meschtscherjakov, Eggen, & Tscheligi, 2017). There have also been efforts by airline companies to use mood lighting in their cabins. For example, Emirates' Boeing 777-300ER has embedded ambient lighting systems that change colors according to outside time. Dubai-based carrier Flydubai also equipped mood lighting system that considers passengers' biorhythms. The different mood lighting scheme gives a greater sense of space with spaciousness feelings.

In such circumstances, theory and research-based evidence about good lighting design is highly demanding. Earlier studies focused on finding optimal lighting conditions to achieve specific emotional effects. The optimal lighting conditions of light properties, such as chromaticity, brightness, and lighting placement, are currently being studied with products that have interior space and illumination. For instance, Raghavan and Narendran (2002) compared consumer preferences between fluorescent lamps and LED lighting in commercial refrigerators. Ran et al. (2015) investigated the effect of lighting placement on visual comfort in refrigerators. Also, Lee, Nam, Kim, and Park (2011) examined the appropriate luminance range of automobile lighting and analyzed the emotions that were felt in response to each lighting color. Caberletti, Elfmann, Kummel, and Schierz (2010) studied emotional responses induced by chromaticity, brightness, and arrangement of the lighting (Caberletti et al., 2010). In parallel, some studies have asserted the necessity to define desired design style of consumer in product lighting. For instance, Choi, Lee, and Suk (2016) extracted affect factors of colored illumination for home lighting to derive context-based lighting presets. More recently, Jeong and Suk (2018) extracted desired design styles by collecting and analyzing refrigerator-related adjectives. Although lighting is regarded as an important factor in product design (Kim, Jung, & Ha, 2010), a few studies has been done with considering emotions desired by customers.

This study aims to find the best lighting combinations which corresponds to the desired design styles on refrigerator. An experiment was conducted with lighting stimuli created by manipulating chromaticity and lighting placement.

2 Materials and Methods

2.1 Lighting Prototyping Tool

We have developed the light prototyping tool named c.light. c.light is a tool that consists of a set of physical modules and a mobile application. The aim of the tool is to support designers to fabricate both tangible and intangible properties of light, especially in the early design

stages of a product. Tangible light property includes the physical shape and the location of a lighting that can be directly touched and controlled. Intangible light property encompasses the light source's color, brightness, and temporal light patterns that are impalpable but are visible to the eyes. c.light can support a concise but effective process that enables users to quickly visualize light design ideas. In addition, c.light supports the development of detailed and elaborate light properties so that users can gain a rich capacity to produce a full range of lights in relation to color, brightness, and temporality. Thus, we used c.light to explore and produce the lighting stimuli in this study.

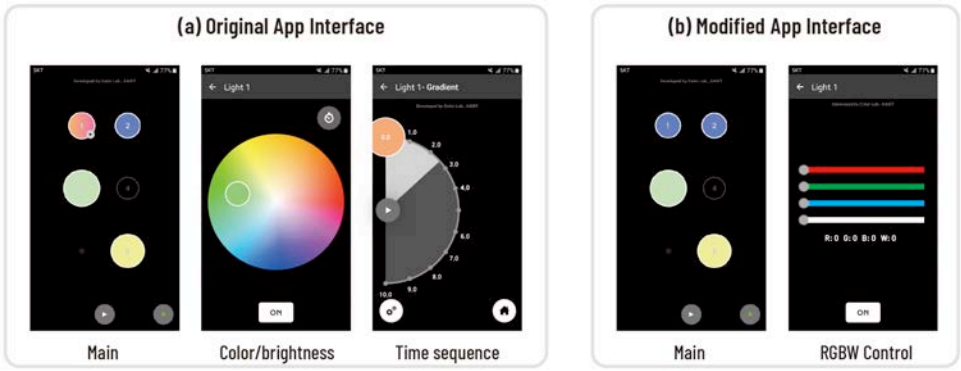

Figure 1. Interfaces designs of c.light: (a) original app interface having wheel type of color/brightness control page and temporality page, (b) modified app interface having bar type control page.

We have modified c.light for the efficient making of lighting stimuli in this study. Modified version of c.light contains surface lighting module, control module, and a modified version of mobile application. The first is a lighting module that can create diverse shapes of lights. Light modules consist of light-strip parts and light guide plates. Light-strip parts contains a built-in RGBW LED strip and those parts can be combined with light guide plate to make surface lighting. Control module is designed to supply power to the lighting modules and to support a connection between the lighting modules and a mobile application. Control module consist of power supply, Arduino Nano, and Bluetooth module (HC-06). The wireless connection enable user to define light property information to the lighting module in real-time. As surface lighting is made up with a series of led chips, it should be operated with a Switching Mode Power Supply (SMPS) having high ampere value.

With a physical prototype of light design idea, intangible properties of light can be intuitively manipulated with a mobile application. The pages of mobile application is designed as concisely as possible to maximize the intuitiveness of the mobile application. The original application includes three pages: (1) the main page for giving an overview of the intangible light properties of each lighting modules, (2) the color and brightness control page, and (3) the temporality page for creating temporal patterns of light (Figure 1). The modified version of application adopts same main page interface and new version of color and brightness control page. The bar type interface was applied to find exact target chromaticity and illuminance value and to gain information of RGBW value.

2.2 Experimental Setup

Eighteen lighting stimuli were created by manipulating chromaticity and placement (Figure 2). Six chromaticity values were selected within the W range of the 1931 Commission

Internationale de l'Eclairage (CIE) chromaticity diagram[1] (CIE, 1932). Three correlated color temperatures (CCT)[2] from the Planckian locus[3] were chosen. The warm, neutral, and cool W had the CCT of 4000 Kelvin (K), 6000 K, and 8000 K, respectively. The other three were white as well but with special hue nuances of yellow-green, bluish-green, and pink.

Figure 2. The combination process with six kinds of white chromaticity and three placements.

LED lightings were installed in an actual refrigerator to provide lighting stimuli, as shown in Figure 3. Adafruit Neopixel Digital RGBW LED strip was chosen as the light source since our lighting stimuli were in W range of the 1931 CIE chromaticity diagram. The W LED could make us to create nuanced white lighting stimuli effectively. To obtain sufficient brightness in the refrigerator, RGBW LED strips were combined with light guide plate for the front and shelf lightings. For the side and ceiling lighting, multiple RGBW LED strips were arrayed and inclined toward the inside so as not to be easily visible from user view.

Figure 3. The ceiling, front, side, and shelf lightings. Ceiling lighting was always turned on.

To make lighting the chromaticity of lighting was controlled by adjusting the pulse width modulation (PWM)[4] values of red (R), green (G), blue (B), and W. Values were sent from a mobile application and then transmitted to an Arduino Nano in through Bluetooth, which was connected to the lighting installations. Ceiling lighting was always turned on to provide adequate brightness for the refrigerator. The illuminance level of stimuli was adjusted to 750

[1] Plane diagram in which points specified by chromaticity coordinates represent the chromaticities of color stimuli (CIE, 2011).

[2] It refers the temperature in units of K of a blackbody whose chromaticity most nearly resembles that of the light source (DiLaura, Houser, Mistrick, & Steffy, 2011).

[3] Locus of points in a chromaticity diagram that represents chromaticities of the radiation of a blackbody at different temperatures (CIE, 2011). In other words, it refers to the path of color temperature in a particular chromaticity diagram.

[4] The maximum PWM value of each single-colored LED is 255. At maximum value, LED could light up its maximum brightness.

lux to confirm only the effects of chromaticity and placement of lighting. The colorimetric value and illuminance level were measured at the center of the second shelf. The experiment room lighting was configured at 6000K and 300 lux. The space brightness was the average illuminance[5] value around the refrigerator in eight Korean participants' dining time, which is the time that the refrigerator is most heavily used.

2.3 Evaluation Criteria

Jeong and Suk (2018) explored users' desired emotions for refrigerator lighting by applying brainstorming method, and almost 1,000 relevant terms were collected. Terms were classified by the Korean thesaurus relationship, and three emotion categories were derived as desired design styles on refrigerator lighting: abstract quality, space perception, and visual comfort. Several adjectives were also introduced as being representative of the three emotion categories. These adjectives were adopted as the evaluation criteria of this study, as shown in Table 1. In addition, the terms "novel" and "satisfied" were added to determine holistic reactions to refrigerator lighting. Novel was added to gauge reactions to new kinds of lighting combinations that are not used in current refrigerator design. Satisfied represents the general preference of lighting stimuli. In sum, a total of ten adjectives were utilized as evaluation criteria.

Table 1 Ten adjectives used as the evaluation criteria in this study.

Source	Adjectives
Jeong and Suk (2018)	appetizing, distinguishable, luxurious, refined, refreshing, spacious, undistorted, visually comfortable
Added in this study	novel, satisfied

2.4 Participants

A group of 177 participants were recruited in the study. The group comprised of women aged 20 to 69, and their average age was 45.38 with a standard deviation of 12.27 years, as presented in Table 2. All participants were paid volunteers without color vision problems. Ethical approval concerning human participants was obtained from the KAIST Institutional Review Board prior to the experiment (Approval No.: KH2017-92).

Table 2 Average and standard deviation of participants.

Age group	20s	30s	40s	50s	60s	**Total**
N	20	36	51	45	25	**177**
Mean (SD)	22.60 (2.21)	35.53 (3.05)	44.78 (2.58)	54.31 (2.64)	62.96 (3.16)	**45.38 (12.27)**

2.5 Procedure

A maximum of three participants took part in the experiment at one time to ensure sufficient viewing angles while looking at the same refrigerator. Participants sat in chairs 50 cm from the refrigerator, and chair levels were adjusted so that the eye level is on the middle shelf of

[5] The amount of light falling on a surface expressed as lux or nit. It is a determinant for identifying if the amount of light is adequate for an environment.

the refrigerator (Figure 4). The lighting stimuli were presented to the participants in random order, and the refrigerator doors were closed while the next stimulus was prepared to minimize the possible impact of the previous lighting stimulus in subjective assessment. The doors were opened again after the next stimulus was prepared. Participants were asked to evaluate how well each lighting stimulus matched to the given ten evaluation criteria with a 5-point scale Likert scale (1 = *strongly disagree*, 5 = *strongly agree*). The experiment took about 30 minutes to complete.

Figure 4. Participants evaluated lighting stimulus at a 50-cm distance from the refrigerator.

3 Results and Analysis

A conjoint analysis was conducted on each evaluation criteria to identify relative importance and utility scores of two lighting attributes. The relative importance and utility scores indicate how relevant each attribute was and how impactful each level was within the attribute, respectively. Figure 5(a) compares the averaged importance values of chromaticity and placement with regard to the spacious evaluation criterion. Chromaticity occupies 63.15%, while placement occupies 36.85 %, which indicates that subjective judgment of the spacious aspect was more influenced by chromaticity than placement. The utility scores of each lighting attribute are revealed in Figure 5(b), which indicates that the best combination for creating a sense of spacious style is cool W-colored front lighting, as the sum of their utility scores the greatest (0.32 + 0.21 = 0.53). A strong positive correlation was found between the ranks of 18 lighting combinations (Kendall's tau = .73, $p < .001$), supporting a high level of reliability for the statistical result.

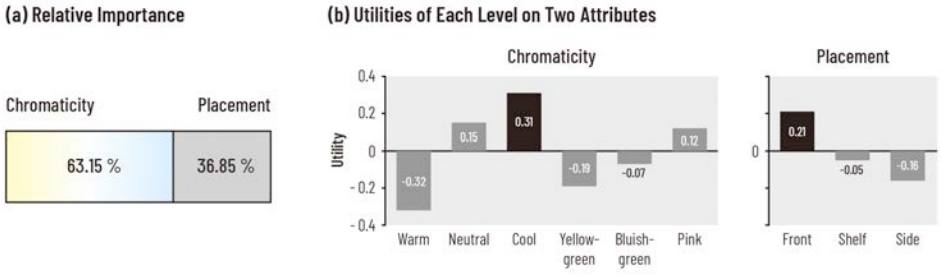

Figure 5 Conjoint result of spacious criterion: (a) the relative importance of the two attributes; (b) the utility scores of levels within each attribute (N = 177).

Table 3 shows the results of conjoint analysis with regard to the entire ten evaluation criteria. The size of relative importance was compared for each criterion, and the level with the highest utility score was presented. In general, chromaticity appeared to be more critical than placement for assessing subjective qualities across criteria, except for the visually

comfortable criterion. Participants considered the placement of lighting more relevant to the visual comfort. Among the six chromaticity conditions, pink nuanced W and Cool W were often the most preferred. In terms of light placement, the front lighting was preferred in general, across the criteria.

Table 3 Conjoint analysis results for ten evaluation criteria. Only the largest positive utility values were described in the table.

Evaluation criterion	Attribute	Relative importance	Level	Utility
satisfied	chromaticity	73.21	pink white	0.25
	placement	26.79	front	0.08
novel	chromaticity	68.39	pink white	0.26
	placement	31.61	shelf	0.08
luxurious	chromaticity	72.43	pink white	0.22
	placement	27.57	front	0.04
			shelf	0.04
refined	chromaticity	75.20	pink white	0.23
	placement	24.80	front	0.05
spacious	chromaticity	63.15	cool white	0.31
	placement	36.85	front	0.21
undistorted	chromaticity	85.67	cool white	0.30
	placement	14.33	side	0.05
distinguishable	chromaticity	73.31	cool white	0.26
	placement	26.69	front	0.12
appetizing	chromaticity	91.77	cool white	0.24
	placement	8.23	shelf	0.02
refreshing	chromaticity	88.69	cool white	0.28
	placement	11.31	front	0.03
visually comfortable	chromaticity	31.76	bluish-green white	0.06
			pink white	0.06
	placement	68.24	shelf	0.09

As the assessments were highly correlated among some criteria, we were able to cluster the ten criteria into several groups. For example, the assessments regarding spacious, undistorted, distinguishable, appetizing, and refreshing were positively correlated, indicating that these five criteria were related to similar aspects. After examined correlations among the assessments, we re-clustered them into four categories: performance, style, visual comfort,

and overall satisfactory. Table 4 presents these categories and their respective criteria. We considered satisfied as an independent category, as it is a holistic measure.

Table 4 Four criteria categories and assigned adjective in each category.

Criteria category	Performance	Style	Visual Comfort	Overall Satisfactory
Assigned adjective	appetizing, distinguishable, refreshing, spacious, undistorted	luxurious, novel, refined	visually comfortable	satisfied

Next, we integrated the conjoint analysis (Table 3) and criteria category (Table 4) to identify the optimized lighting conditions that best serves each criteria category. For example, to enhance the overall satisfactory, a pink nuanced W light placed toward the front should be the best among the eighteen lighting combinations. However, this would not be as successful to achieve well-functioning impression. In this way, designers can alter the chromaticity and placement of light depending on desired product concerns, just like any other design activity to visualize forms and shapes. Table 5 shows the best chromaticity and placement lighting combination for each of the four criteria categories.

Table 5 The best matches of chromaticity and placement of light to each of the four criteria categories. The illuminance level was fixed to 750 lux in all combinations.

Criteria category	Performance	Style	Visual comfort	Overall Satisfactory
Image				
Chromaticity	cool white	pink white	bluish-green white	pink white
Placement	front	shelf	shelf	front

4 Discussion and Conclusion

This study examined user preference of refrigerator lighting based on chromaticity and placement lighting. We assessed a total of 18 lighting variations by combining six chromaticities and three placements. Ten adjectives were selected as the evaluation criteria and participants subjectively judged with these criteria. Based on the assessments, we performed a conjoint analysis and quantified the impact of lighting attributes between chromaticity and placement. In specific, we identified combinations of these two attributes that best serve the each criteria. Moreover, the ten criteria were clustered into four

categories, and we employed them as four refrigerator concept alternatives. We finally summarized the optimal combinations of four lighting concepts as described in Table 5.

As we recruited women aged 20 to 69, we noticed that age affected their refrigerator lighting preferences. In perspective of the brightness of lighting, a previous study found that older people prefer higher luminosity due to the normal aging of their vision (Winn, Whitaker, Elliott, & Phillips, 1994). Less illuminance reaches the retina since the pupil size decreases with age (Winn et al., 1994), and this explains why older people require higher illuminance levels. In fact, we observed similar tendency that older participants preferred the front placement of lighting, while younger ones favored indirect lightings. In terms of the chromaticity of lighting, the preference on chromaticity level was also differed by the age. For example, older groups showed stronger preferences for the pink nuanced lighting, while younger liked cool W. In the future study, we should analyze the age effect on preference of the refrigerator lighting conditions.

The findings in this study are limited to the given experimental settings. For example, this study recruited only female users. Although the majority of the user in Republic of Korea was women, the sex-dependent preference might be reflected in the result. Future study should consider even number of male and female user population. In addition, the space lighting should be also differentiated to draw conclusions with higher practical implications. Methods and theories should be customized to optimally fit to given items and contexts.

Nevertheless, this study is one of the practical approaches that has involved actual lighting stimuli and explored aesthetic quality judged by people. Although more advanced experiments should follow, this study provides data designers can articulate for their design practice. We expect this study will encourage further human-centered lighting studies to contribute to a reliable database that designers can easily use to develop new ideas in design practice.

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System Autonomy, Personal Indoor Farming and User Preference

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Increasing attention has been paid to Personal Indoor Farming since healthy, sustainable and home grown food supplies are emerging as a lifestyle trend. Although the existing appliances for personal farming are becoming more innovative, they have not had a large commercial impact. A possible reason is because of a lack of understanding of potential users. In this study, a preliminary interview with 31 users found that Personal Indoor Farming is perceived as a more emotional activity than food production. However, a contradiction was revealed between a desire to grow personal crops and fear of failing in cultivating them. Based on this insight, a taxonomy of autonomy level in Personal Indoor Farming was defined through literature review. Through the taxonomy, eight scenarios were generated from a designer workshop in terms of four autonomous levels and two extensibility levels. The scenarios were evaluated by 45 respondents in order to investigate the preferences of users according to the autonomous level. The results suggest that people prefer a mid-level of autonomy in farming products that support them in caring for their crops. To conclude design implications are proposed to support the design of more appropriate indoor farming products and product services.

Keywords: Personal Indoor Farming; user experience; user preference; level of autonomy

1 Introduction

Reliability of food materials is an increasing issue in an industrial environment that cannot be free from chemicals. Product or service solutions for more reliable and fresh food are being developed in various ways. Among them, Personal Indoor Farming (PIF) is a form of growing food in a trusted, fun way to access fresh, home grown produce (Blanche, 2015). In this study, the term *PIF* is used to focus on indoor farming, not for mass production but for personal use.

For example, products for hydroponics in indoor homes are better known to the public initially through crowdfunding projects. For example, product companies such as Click and Grow (Worldwide), Aerogarden (USA) and Plantui (Europe). However, without agricultural experience, it is not easy to put effort into cultivating plants. As a result, existing products usually have LED lighting that can compensate for the lack of sunlight, and pod capsules that combine artificial soil and seeds that are optimized for the product. Additionally, the application components of existing solutions record growth of crops, or provide information to the user during growth. These solution allow users to grow their own food at home..

The current study aims to explore the challenges and opportunities for design to provide solutions within the indoor farming space.

An initial user study interviewed 31 people (*n=31*). Criteria for selection included participants who conducted PIF or have done so. Participants were encouraged to share emotional anecdotes on their PIF experiences. Users were further asked to talk about their own reason to engage PIF (Figure 1).

Figure 1 Interviewees' gardening photos posted to their social media accounts

One of the interviewees responded that he is no longer engaged in PIF after bugs' attacked his veranda which led his PIF crops to die. His description of plants indicated their pet-like quality or the things to share emotions with. Another interviewee shared his story of when he started indoor farming for his young daughter and it became a daily routine of family activity to plant the seeds, water the sprouts and juice the grown kale leaves to drink in the morning. He emphasized the emotionally relieving effect and also meaning as a family leisure activity.

When participants were asked to talk about the reasons to stop engaging PIF, for the majority of the interviewees, answers related to concerns over time and busy life styles.. One interviewee said, "It was so sad and I felt guilty when finding all the crops dead, one day opening the veranda door. I was so busy at that time so that I forgot to water them. Also it was a really hot summer unfortunately."

Surprisingly, there are already innovative solutions existing to help PIF, while those solutions are not easy-accessible. According to a research by Jansen et al. (2016) under the title of 'Attitudes Towards Vertical Farming at Home: A User Study', the study interviewed people regarding their experience with the closed type of PIF product and recorded participant reactions. Regarding the product, some interviewees showed positive attitudes in terms of easiness of caring by automation. However, others showed negative emotion related to an inability to provide personal care, describing a need for an empathetic attitude towards the crops.

One study related to emotional bonding to personalized product suggests a conceptual model regarding the efforts put in to the product and the relationship with emotional bond as a result. (Mugge, 2009) The concept brings an issue related to just how much effort is required to achieve emotional bonding within the PIF space.

PIF is an activity that people inevitably put efforts into caring for their plants. That might be why people conducting PIF mention their emotional experiences as the more plants grow, the more people have put efforts into obtaining the reward of seeing the fruit of their labour so to speak. According to a study of Mugge (ibid), efforts invested can influence emotional bonding. On the other hand, autonomy may result in less effort in their indoor plants. Thus, while the convenience of technology ensures efficiency and effectiveness, it does not ensure people's emotional experiences. Furthermore, in the context of PIF, it is critical issue as people pursue emotional experiences.

The dilemma begins with the goal of healthy crop harvesting. Achieving that goal requires complex knowledge and skills, with users spending their time constantly during long-term periods to take care for their crops and the cultivation of the planting environment. Chances to fail are high. On the other hand, users want to feel the reward from a certain amount of effort in their PIF approach.

It is true that it is very efficient to receive help from technology. And people want to be able to grow their crops while satisfying their emotional motives of 'growing their own crops'. Here, conflicts are found, people are not fully attracted to the development of crops without human intervention in a fully autonomous system. Thus, in this study, we hypothesize that there is a degree of appropriate autonomy in the dilemma between rewards and perceptions of technology dependence.

While user studies of the PIF approach were found to be scarce, a study was identified that describes the necessity of user studies on vertical farming products in terms of technology acceptance (Jansen, 2016). Based on interviews with a working prototype, it was found that while interviewees wanted some sense of control over the automated system, participants also showed some skepticism on the technology-based food innovations related to concerns over food safety.

However, unlike the field of intensive research on autonomous driving, there is little research on autonomous systems in PIF. Therefore, in this study, factors that constitute the autonomous stage in the preliminary study of the unmanned system have been referred to in order to build a taxonomy for the autonomous product systems of PIF.

In order to define the factors necessary to determine the autonomous steps mentioned in the unmanned system also in the autonomous system of PIF, the knowledge of the plant factory system and the large-scale, autonomous agricultural system was referenced and the farmers' behavior theory was also referenced.

Essence of PIF

From the big scale standard, the stage notions were adapted while the crop-care is classified into more detailed and easily recognizable terms. On the other hand, as PIF is in the more controlled indoor spatial context, concepts and mechanisms such as weed related ones were excepted from the element. As a result, there are 7 elements narrowed down and expected user issues are added referred from the preliminary interview.

Seed & Seedling
The first step in PIF is planting seeds or seedlings. It is also important to purchase proper seeds and seedlings, and to equip them with the tools necessary for cultivation. In hydroponic cultivation, there are various culture mediums, and it is necessary to select and use it according to the crop. It is also critical to plan and estimate the crop consumption for the appropriate amount of cultivation. Expected user issues are how much we should plant to grow the proper amount, how many seeds should be planted in a pot, how much moisture the seeds should keep, and what should we plant.

Fertilizing
There are many ways to give enough nutrition. Depending on the type of vegetables such as leafy vegetables, root vegetables, fruit vegetables, etc., nutrients are slightly different, but the nutrients used for hydroponics usually are distributed on the market in the form of powder diluted or nutrient solution. In the case of nutrients, the recommended total DS (Dissolved Solid) for each crop is different, requiring a different nutrient concentration for each crop. At too high concentrations, the roots may become necrotic. At too low concentrations, leaves and fruit may become inadequate for ingestion, especially if root vegetables are not well developed. Expected user issues include how much and often they need nutrition, and what nutrients we put in.

Air Conditioning
Plants breathe through their leaves. Leaves emit moisture through pores according to the temperature

and also light. While the hydroponics in the room usually share the indoor air that is suitable for humans, problems of low or high temperature are minimal. However, if the crop is sensitive to temperature, the window-side can be an issue as it can freeze the water during winter season. For some crops, ventilation is very important If they are not well ventilated, they can quickly die. Carbon dioxide is necessary for plants to perform photosynthesis. It is a great help if the users ventilate to help photosynthesis. Expected user issues are proper temperature, if air-conditioning house is appropriate and at what level, and ventilation questions.

Irrigation

Because hydroponics exposes roots, the temperature around the root changes more easily than when it grows in the soil. In particular, the temperature of the entire hydroponics system rises and falls rapidly due to air temperature and light intensity, so careful management of the nutrient solution temperature is necessary. Roots are the most important part of plant growth. Healthy plants have white and durable roots. In the Kratky method, the roots follow the water without supplementing the nutrient solution. The rest of the roots exposed above water level absorb the oxygen in contact with the air. So, users do not need to add more water and naturally it is much better to leave it in terms of oxygen supply. Some crops are better to grow at high-temperature, others are low-temperature crops. Outside this range, nutrients and water absorption capacity will decrease and growth will be inhibited. User issues include how often water should be changed, how often the user should give water, how much water there is, and whether the temperature of the water is moderate.

Lighting

Every plant needs light for photosynthesis, and depending on the type of plant, some may live with less light, but most of the time they have enough light. Unlike indoor ornamental plants, especially those grown in garden gardens, growth rates are much faster and require as much light. Each plant has an optical compensation point and a lightning point. When the amount of light is above the light compensation point, the crop begins to grow, and as the light gets stronger, it grows faster and grows stronger. And when it becomes a bandage, it does not get faster even if it is lighted any more. When the amount of light is small, the leaves are small, and the stem becomes thin fragile. Therefore, if there is a place that can receive direct sunlight for at least several hours, it is better to bring the plant out and put it back again. And even if you leave it indoors, the user will need to arrange it in parallel to the window with the best sunlight to get a little bit of light. If this effort is insufficient, the user needs to use artificial light to supplement the light.

Crisis Management

Plants do not always grow up straight and right. The concentration of nutrient solution can be too high to melt the roots, or the light may not be enough to cause over growth. Properly dealing with these problems is also an essential part of indoor personal farming. If the user removes over-grown leaves, they can help other small leaves grow. The advantage of hydroponics is that it can be ascertained by lifting the roots, but if the roots are darkened neurotically, they should be cut off to allow the new roots to grow. The biggest disadvantage of hydroponics is that if the water is contaminated, pests are spread rapidly through the water and there is a risk of food poisoning.

Harvesting

In order to harvest, it is possible to grow the plant after it is fully grown. Especially in the case of leafage, it is possible to harvest the leaves with leaves that can function as photosynthesis more than a certain amount. When the new leaves are not long enough, if the user cuts the big leaves first, the plant will not be able to receive the nutrients made from the big leaves, so the growth rate will slow down. When cultivated through hydroponics, the growth rate of crops is fast, so small leaves are produced. Leaves that grow to the appropriate size should be cut in time to make a shape and make space so that more leaves can be harvested. If the user wants to make the stem longer, cutting the top growth point will allow more leaves to grow. Weighing the harvested crops can be an indicator of cultivation performance. Expected user issues include how much the user can harvest, how long the plant lasts after harvesting, and when the crops should be removed.

Taxonomy of system autonomy in PIF

In order to define a taxonomy of system autonomy in PIF, the framework of Farmers Adaptation Behaviour was investigated (Figure 2). According to the framework, there are six elements related to farming behaviour: Awareness, Perception, Behavior, Media, Network and Intention. Perception means our sensory experience regarding the surrounding world and also covers recognizing environmental stimuli and reaction to these stimuli (Rezaei, 2017). In the context of PIF, the example can be: the basil seems weak and the lighting might not have been enough all day long. The awareness refers to the concern or recognized issue towards environmental problems. In other words, an aware user realizes dangers and difficulties and knows that he/she may be in trouble. When an environmental problem is realized, the awareness will improve and increase the understanding. For example, a farmer is aware of water scarcity because it may affect productivity (Sudarmadi et al., 2001).

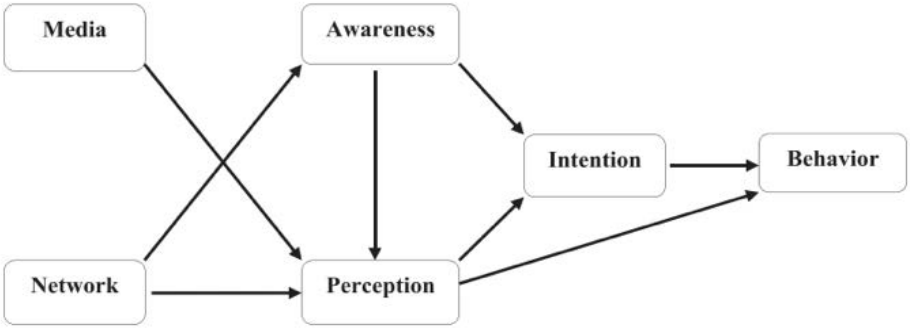

Figure 2 The theoretical framework of Farmers Adaptation Behavior (Rezaei, 2017)

Considering the autonomous system in PIF as not a group of things but a single system, the critical and relevant elements are awareness, perception and behaviour to perform within a certain environmental context. Referring the farmer's adaptation elements, now the PIF axis can be defined in detail as follows: Mission, Environment and Human Independence can be re-interpreted into the set of Awareness, Perception and Behaviour. In conclusion, the level of system autonomy in PIF is defined as in Figure 3 below by distinguishing human independence of each stage through awareness, perception and action.

Level 0	Level 1	Level 2	Level 3
• Awarenss made by system only. • Perception acheived by human only • Action through human only	• Awarenss made by system only • Perception by both system and human • Action achieved through human only	• Awareness made by system only • Perception by system only • Action done by both system and human	• Awareness made by system only • Perception by system only • Action done by system only

Figure 3 The level of system autonomy in PIF defined for the study

2 Experimental design

In order to create scenarios in relation to each level of system autonomy for PIF, a designer workshop was conducted. Eight scenarios were devised as the specimen to be evaluated by potential users in terms of preference. Then, an experiment was performed to find out the preference of potential users among the autonomy levels, utilizing the eight scenarios (Figure 4).

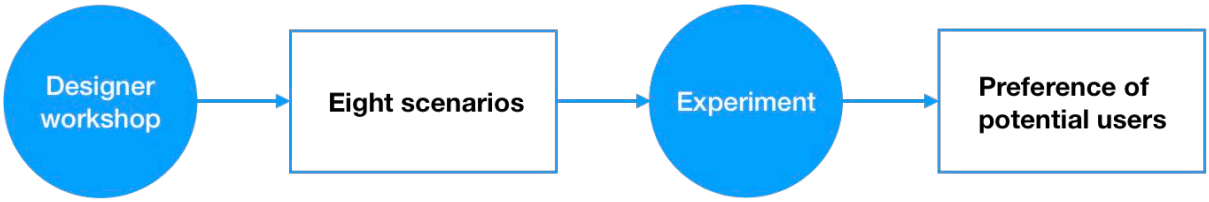

Figure 4 The experimental procedure in the study

2.1 Designer workshop

2.1.1 Participants

A total of 13 people (*n=13, 6 males and 7 females*) participated in the designer workshop and their age ranged between 26 and 31 years old. They were recruited from the researcher's network at their home institution. Because of the purpose of the workshop, participants had at least one-year experience in design practice and also their backgrounds were rather diverse in terms of expertise which ranged from product design and graphic design to interaction and service design.

2.1.2 Materials

Based on the process of indoor personal farming, a set of cards was made in which each process is described in detail with related examples to help workshop participants clearly recognize each process (Figure 5).

Figure 5 A set of cards illustrating the seven essences of PIF used in the workshop

Design cases boards were also produced to let the participant clearly understand each level of system autonomy based on the four levels of system autonomy in PIF (Figure 6). In the boards, images of related technologies and examples according to each level of system autonomy were attached. The design cases include products with variety of interaction. The case cards were provided to evoke discussion on the definition of the autonomous level. It was to let the participants discover design issues by themselves in terms of autonomous system by fusing their knowledge during discussion.

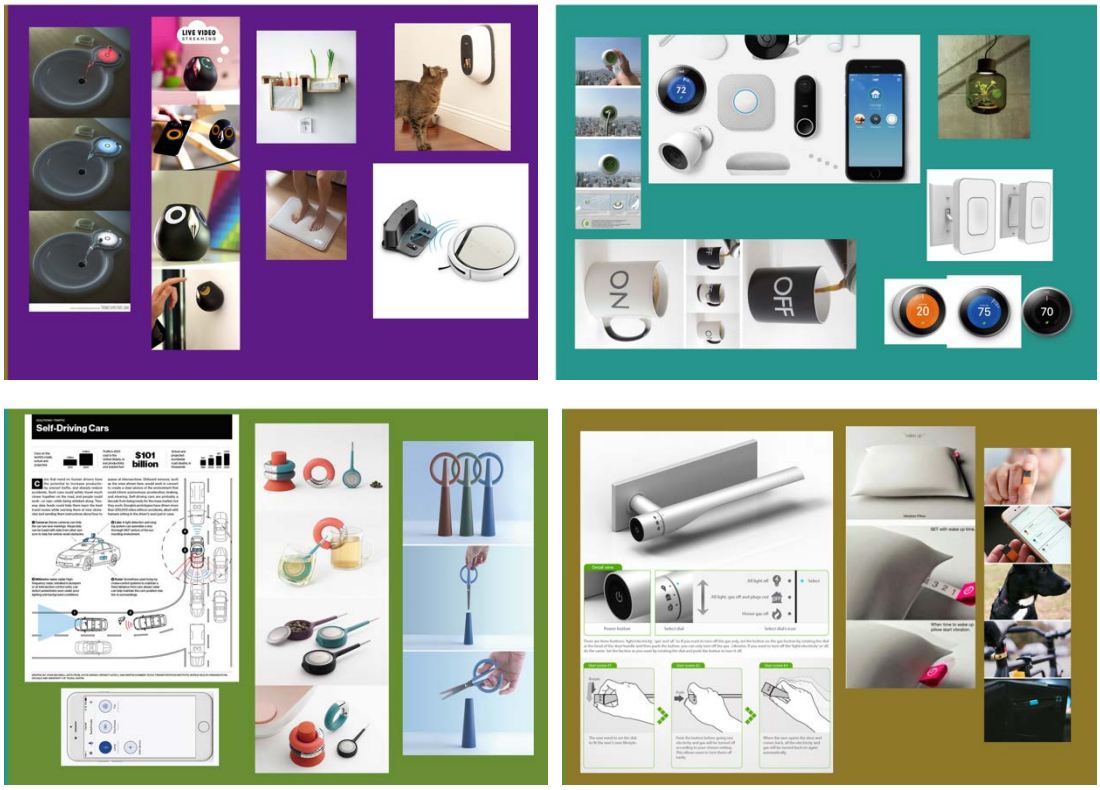

Figure 6 Workshop Material Used for Case Sorting to Discuss Regarding the Definition of Autonomous Level

2.1.3 Procedure

The designer workshop consisted of four sessions: ice-breaking, knowledge acquisition, card sorting and scenario making sessions. First, the participants were invited to a meeting room provided by an office sharing company. The session of ice breaking started with a coffee time and the purpose of the workshop was introduced. This was followed by introducing all the participants themselves to each other sharing their interests, professions and the motivation of participation. In the second session, a 15-minute general introduction regarding PIF was given based on market research of existing products for PIF and knowledge on plant factory and PIF gained from literature review. In the session, the participants were asked to match cards together according to the seven phases of PIF (Figure 7).

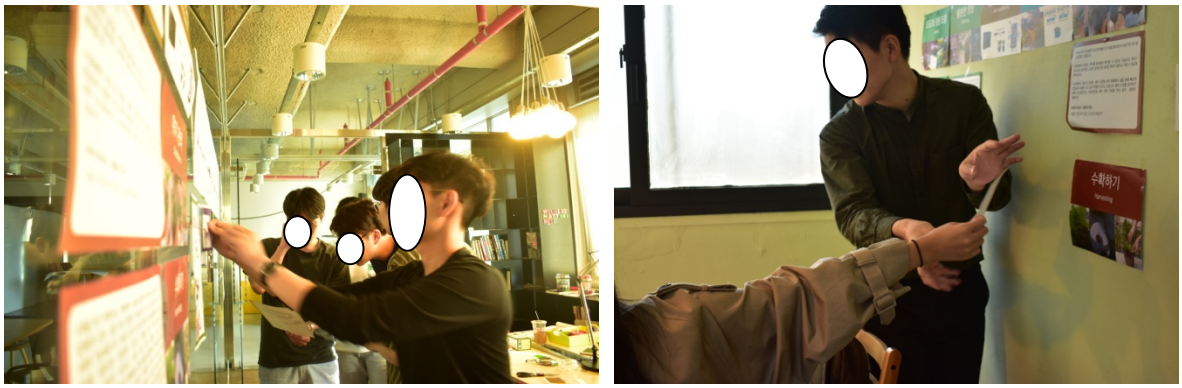

Figure 7 scenes of the card matching session

In the scenario making session, a 20-minute general introduction was provided regarding system autonomy based on the cases of autonomous driving and the literature review on scenario-based study on autonomous driving levels. This was followed by sorting design-case boards according to the levels of system autonomy for PIF (Figure 8).

Figure 8 A scene of card sorting according to system autonomy level for PIF

In the last session, participants came up with as many scenarios in relation to each level of system autonomy for PIF as possible (Figure 9). For each level, only 10 minutes was given so that participants could concentrate and keep up an intense pace. The sorted cards from previous session were all posted on the walls so that participants could keep reminding themselves of what they had learned from the prior sessions.

Figure 9 A scene of generating scenarios for each level of system autonomy in PIF

2.2 Scenarios according to the level of system autonomy

As a result of the scenario making session, 53 scenarios were generated in total: 10 scenarios for level 0, 11 for level 1, 11 for level 2, and 13 for level 3. First, 45 out of 53 scenarios were selected after reviewing with two external indoor farming experts in terms of quality and feasibility for PIF (see an example in Figure 10).

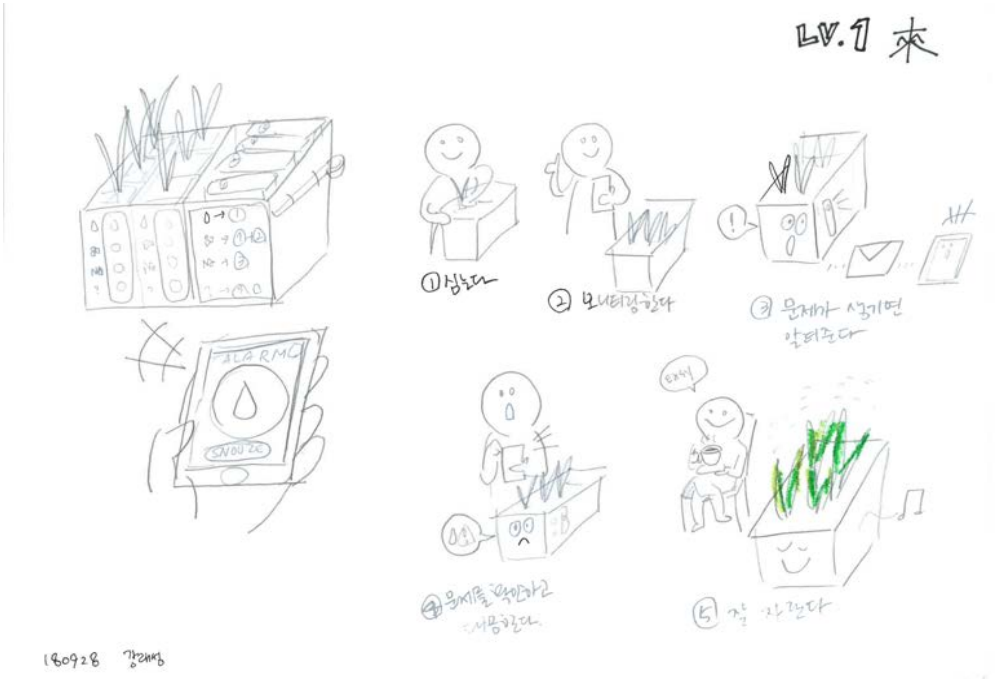

Figure 10 An example of the scenarios generated from the designer workshop

Ideas were evaluated in terms whether they could be extendable with services or accessories can be considered along with the system autonomy. From the workshop with designers, participants suggested potential solutions utilizing mobile devices and IoT (Internet of Things) technologies. As the current study pursued future products, the scenarios distinguished extensibility. Extensibility is divided into high and low depending on whether there may be system elements that can provide continuous updates beyond the initial purchase, or whether there is expansion connectivity with product systems other than purchased. Therefore, concepts were categorized through two notions, level of system autonomy and extensibility. For example, when comparing two scenarios for level 3, low extensibility scenarios produce crops by controlling the environmental conditions in a confined product environment. On the other hand, high extensibility scenarios are designed to control the environmental conditions of crops in open environments by allowing peripheral appliances and products to communicate. As a result, eight exemplar scenarios were selected in terms of level of system autonomy and expendability (Figure 11).

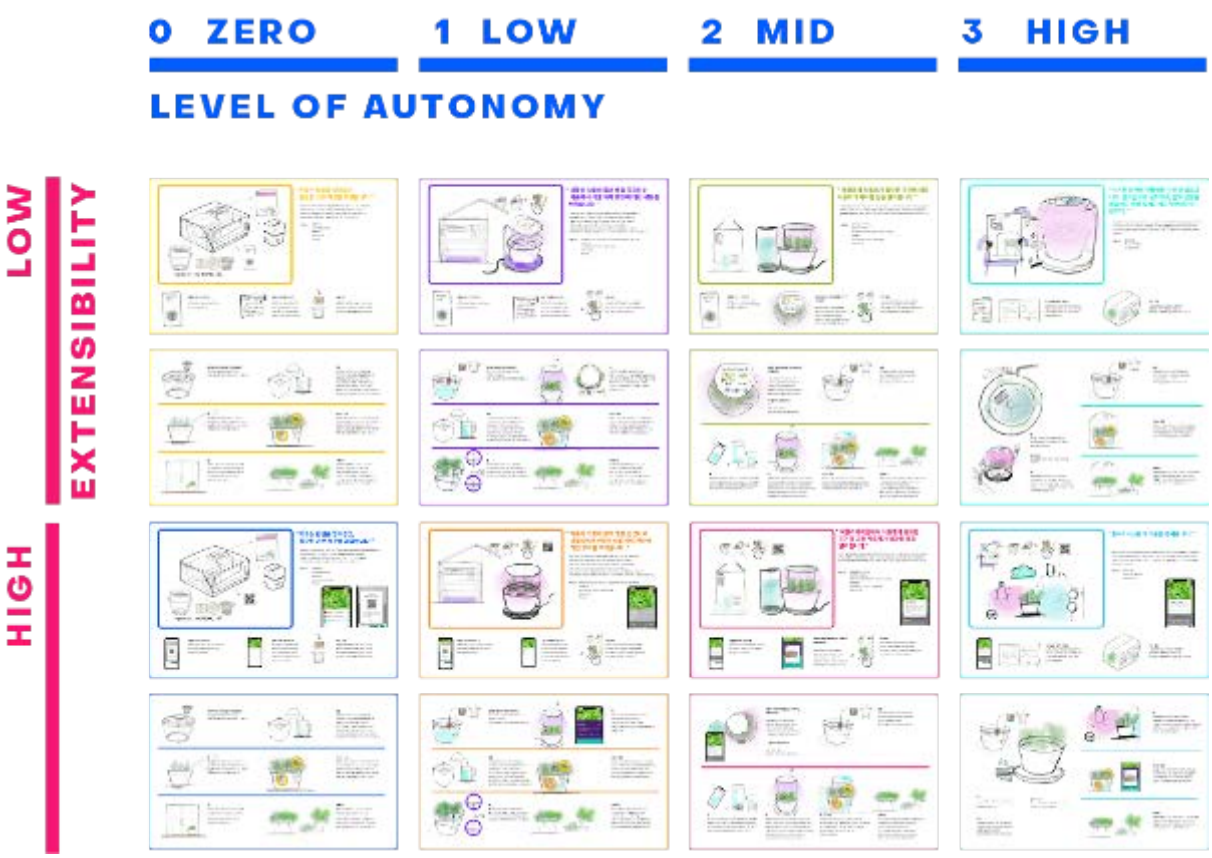

Figure 11 The eight exemplar scenarios of PIF in terms of level of system autonomy and expendability

2.3 Experiment

2.3.1 Participants

Participants were recruited according to level of experience, the experienced and the in-experienced. The recruiting was selectively executed. Internal and external communities from in and around the authors' institute is located were identified. For the internal channel, the school's SNS community was utilized mainly to recruit in-experienced subjects. To recruit participants with a variety of lifestyles we actively recruited both on and offline. Recruiting posters were posted nearby community focusing on village areas and also people were recruited through some acquaintances. By utilizing social media, the card type of introductions was posted, and it actually succeeded to gain some plant lover participants over distant areas. In total, 46 participants answered the prepared questionnaires and 45 sets of data were collected for analysis, 22 from the experienced group and 23 participants from the in-experienced group.

2.3.2 Materials

A short questionnaire was developed to identify if she/he is a potential user of PIF in the future. Questions asking for her/his demographic information (Figure 12).

P Personal Indoor Farming Related Information	Do you have willingness to farming in your space?
	How much time do you have viable for personal indoor farming?
G Generic Information *Not in Likert scale	Gender
	Birth Year
	Nationality
	Vocation/Job
	Housing Lifestyle
	Number of people living with

Figure 12 Survey Questions About Basic User Information

The eight scenarios were made in the form of cards on which all the information is illustrated to help participants clearly understand what each scenario stands for (Figure 13). One scenario consisted of two cards: one showing an exemplar product with detailed information and the other explains characteristics required in the indoor farming process (see Table 1 for details).

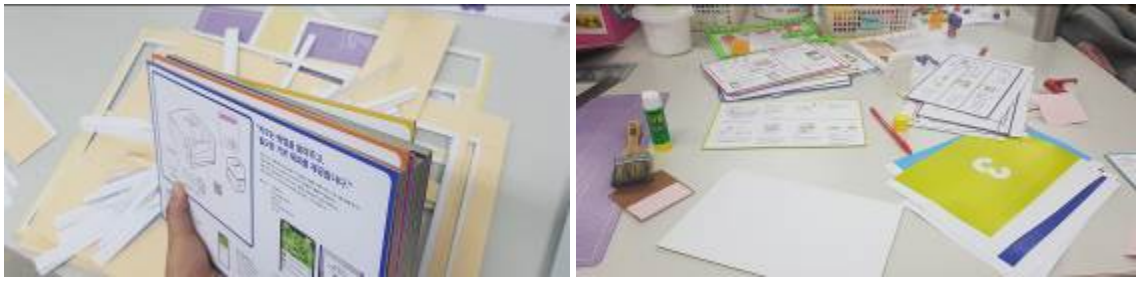

Figure 13 Scenario Card Fabrication

Table 1 Scenario feature specifications used in the study

S#	Info1	Info2	Main Product Type	Components	Type of Seedling and watering	Nutrient and lighting	Sensors
1	Manual Book	Checklist	Main Product	Port and Bed	Seed	Nutrient Powder	
2	Manual Book	Checklist	Main Product + Sensor Data Visualization	Port, Bed and Seed	Water Gaze Signifier	LED Lighting Timer	Temperature Degree TDS Degree
3	Manual Book	On-product Display	Main Product + Instruction Visualization	Port, Bed, Seed and Nutrient	Water Tank Top	Light Saturation in Face Icon	Temperature In Color
4	Manual Book	Delivery	CLOSED TYPE Main Product	Port, Bed, Seed and Nutrient	Built-in irrigation	Lighting Automated	Temperature Automated
5	Manual App	App Diary	Main Product	Port and Bed	Seed	Nutrient Powder	
6	Manual App	Data shown through App	Main Product + Sensor Data Visualization	Port, Bed and Seed	Water Gaze Signifier	LED Lighting Timer	Temperature Degree TDS Degree
7	Manual App	Push Alarm	Main Product + Instruction Visualization	Port, Bed, Seed and Nutrient	Water Tank Top	Light Saturation in Face Icon	Temperature In Color
8	Mobile App Augmented Services	Delivery, Recommend Push	OPEN TYPE Main Product + IoT hub based	Port, Bed, Seed and Nutrient	Built-in irrigation	Home hub lighting control	Home hub temperature control

2.3.3 Procedure

Participants were asked to make a visit at a designated time to conduct a survey and interview offline. The total test time was within one hour. As all the questions are based on the 'What-if' situation to reflect themselves using the virtual product system, the information on what users are to do for conducting PIF was provided in advance through a 10-minute lecture. The information provided was the same provided to the participants of the scenario generation workshop. After the simple lecture on the essence of PIF, participants had time to look over the scenario cards without the questionnaires to check for comprehension on the scenario sketch and the explanations. After the card scanning session, participants were provided with cards one by one in randomized order, and they chose the best scenario card for her/him. This was followed by an interview in which we asked why she/he chose it as a best idea for PIF.

3 Results

When the interviewees were asked to answer what their best scenario is, 15 out of 45 answered scenario number 7 with autonomous level 2 and extensibility level high (Figure 14). Scenario number 3 also with autonomous level 2 gained 7 out of 45 and recorded to be the secondly preferred scenario.

When the interviewees were asked to answer what their worst scenario is, 17 out of 45 answered that scenario number 4 with autonomous level 3 and extensibility level high. Scenario number 1 with autonomous level 0 gained 11 out of 45 and recorded to be the second worst scenario.

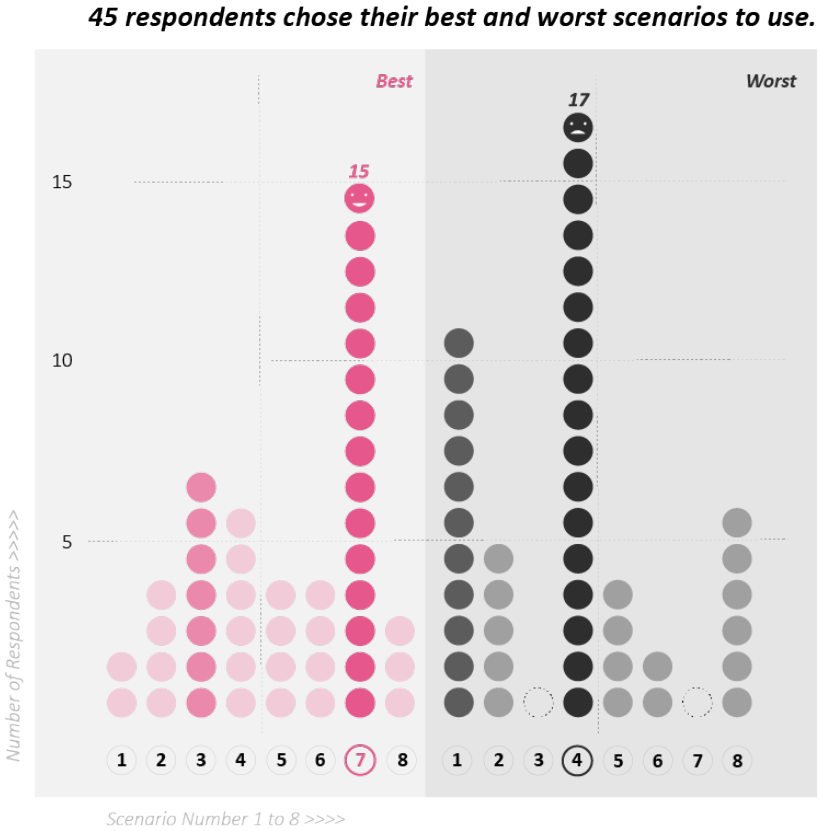

Figure 14 Frequencies of user preference in 8 scenarios

For the best scenario, scenario number 7 from autonomous level 2 was the best scenario and the second preferred scenario was also scenario number 3 from the same autonomous level 2 (Figure 15). While the result is not enough to be generalized, there was meaningful issue found according to

the interview after the survey. When the interviewees were asked to answer why they chose the best scenario as the scenario number 7 and 3, participants responded that they liked them as they felt to have a system like an 'air bag' so as not to make their crops dead. At the same time, they chose the scenarios with autonomous level 2 expecting to raise their crops in person by their own efforts.

Figure 15 Scenario Number 7 with Autonomy Level 2 (Mid) and Extensibility Level High (The Most Preferred Scenario)

For the worst scenario, scenario number 4 from autonomous level 3 was chosen. According to the interview after the survey, when the interviewees were asked to answer why they chose the worst scenario as scenario number 4, subjects answered that they did not like them as they felt that they could not interact with their crops at all. Some answered that if the crops are not raised by their efforts, they would rather choose to purchase the organic crops at the grocery store than raising it by themselves. Also, every respondent said scenario number 4 would be the most expensive solution among the 8 scenarios and it influenced people not to choose it as a best solution (Figure 16). At the same time, a couple of interviewees said it seems to be too ornamental and not proper for their food product purpose.

Figure 16 Scenario Number 4 with Autonomy Level 3 (High) and Extensibility Level Low (The Least Preferred Scenario)

4 Design implications and Conclusion

First of all, this study is meaningful as a preliminary user study on a wide range of scenarios according to the autonomy stage, in the situation where there is a lack of user research towards optimal approaches to PIF design.

It also means that it can be the basis of a methodology for designing a smart or autonomous solution for PIF by bringing together groups of creatives, such as developers and designers. Our findings are expected to be useful as practical knowledge and as a case study in the field of PIF. There are many smart appliances on the market today. In that context, it is meaningful as a study for the lifestyle of innovation, that is, the optimization of technology. Although this is a case study specific to PIF

solutions, it is necessary for designers to recognize the delicate approach to user interaction based on a phased approach to an autonomic solution as attempted in this study.

On the other hand, research is based on a hypothetical scenario. Therefore, it is necessary to experiment with actual product prototypes in actual time. Depending on the interaction and control methods, there are many ways to give users involvement, and there are plenty of themes to resolve through further study. For example, how might particular types of crop implicate a desired level of autonomy? How might individual differences in user attitude, character or experience implicate a required level of autonomy?

Therefore, it is necessary to study the concept development for various control methods and interaction designs. In addition, economic factors and consumer factors as consumers need to be more complex and specific. By integrating these elements with the concept of the autonomy stage taxonomy initially propositioned in the current study, more appropriate PIF solutions may be achieved that batter address the contradictory requirements of autonomy and personal care towards PIF.

It is meaningful as a further study of how users feel about autonomous technology. It is necessary to investigate how to utilize various concepts and technologies to make practical use in further studies, and to explore whether PIF can be a sustainable alternative to future city lifestyles.

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Systemic Home Handbook: towards a more healthy and sustainable living

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Generally, most products sold on the market come with a short paper or digital guide, aimed at facilitating use, maintenance and, in some cases, the assembly of the object purchased. However, these guides aren't always interesting and easy to understand. Consequently, they are often forgotten about or consulted only when strictly necessary. But what happens when an instruction manual accompanies the use of an apartment and all the elements within it? The purpose of this article is to describe a real case of the design of a *Home Handbook*, conceived as a complete tool to help solve frequent daily problems related to the use of products, components and spaces within the average home. Using a typical *Systemic Design approach*, the project aims to encourage the adoption of a more sustainable lifestyle at environmental, social and economic level, providing useful advice to change incorrect daily behaviour with a high impact. The aim is to make users act spontaneously and consciously, in order to promote more sustainable living which is more attentive to the environmental and social dynamics that are currently devastating the planet. The project is being applied in Milan, Italy, particularly in the recently developed Smart Uptown District and will be initially distribution in the apartments of the housing complex in question.

Keywords: Home Handbook, Systemic Design, Holistic Approach, Behavioural Change, Healthy and Sustainable Living

1 Introduction to the Home Handbook project for the Smart Uptown District (Milan, Italy)

Nowadays, almost every object on the market is accompanied by an instruction manual. Whether it is a single sheet of paper, a booklet or a digital guide, in most cases it is ignored or glanced at briefly after purchase or when a fault occurs. Therefore, the design of everyday objects is combined with the design of practical guides to facilitate their use. There are currently technical handbooks for the use and assembly of household appliances, technological devices and cars, or simpler guides for interaction with very different product categories, from detergents to furniture. Rarely, however, has an effort been made to design a handbook to guide users in the interaction with their homes, understood as systems of interdependent components, which exchange flows and matter with the surrounding world. Yet, the economic outlay required to buy an apartment outweighs that of most everyday objects. And unlike other things, a home is an element with which the user wishes to interact comfortably and safely on a daily basis, for prolonged periods or even for an entire lifetime.

Inside their homes, users perform multiple actions and interfaces with increasingly technological components and complex systems, which can often only be understood by designers and technical professionals. The complexity hidden within the elements that fill our homes today, aimed at making our lives easier, often emerges in the event of failures and malfunctions that are hard to manage without help. This puts the individual in a situation of uncertainty about the best behaviour to adopt to solve the problem or makes them want to take the easy way out. This highlights the absence of a form of prolonged assistance[1] by construction companies or sales agencies, which translates primarily into a failure to communicate the way to solve the most frequent domestic problems and the most efficient and durable action to take (Goffin, 1998; Goffin e New, 2001).

On this basis, a research project on the *Home HandBook* has been carried out at *Politecnico di Torino*, in order to accompany users in the use of domestic spaces and the elements within them, guiding them in the understanding of the most technical systems, supporting them with correct maintenance and encouraging them to adopt sustainable practices at environmental, social and economic level. This project involved cooperation with *Euromilano SpA*, a leading company in the real estate sector, which enabled the design team to interface with a real case, that of a *Smart Uptown District*[2] (Milan, Italy). A building project was developed, providing users not only with accommodation but also with a series of services to implement the living experience, with a view to increasing the level of wellbeing of the tenants.

The aim of the Home Handbook project is to improve the quality of the services offered, representing a long-term tool. The purpose of this article, using an existing case study, is to explain how design can guide users through their daily lives at home, providing helpful tools and know-how to solve seemingly complex problems, along with advice aimed at encouraging more sustainable practices at environmental, social and economic level.

2 Methodology and Guidelines

A precise methodology was used to design a handbook that can offer a holistic home assistance service while also offering qualitative suggestions for more conscious and sustainable living (*Figure 1*). The first step was to identify the initial goals, which can be summarised in three groups, as follows:

- the simplification of solving problems related to the use of new technologies with which the user interfaces inside Uptown apartments;
- the facilitation of the understanding of domestic technical systems, such as the climate system, the energy system and the one related to water flows, for a more efficient use of the home;
- the development of more environmentally, socially and economically sustainable housing and the achievement of a broader overall standard of living.

[1] The importance of a form of prolonged assistance after the purchase of a product, a service or a space was investigated by K. Goffin, who developed a kit of guidelines related to the design and success of innovative products. In particular, he has theorized the need to design after-sales services able to positively affect the customer's general satisfaction. Please, see Goffin,1998.

[2] The *Euromilano project* for the apartments located in the *Smart Uptown Distric*t has provided for numerous partnerships with suppliers of furnishing elements, engineering companies and specific operators for professional interventions within the homes. See the official website: www.euromilano.net

A Desk Research phase and a Field Research phase were subsequently carried out, both of which were essential to the drafting of a precise set of guidelines for the initial elaboration of the Home Han*dbook concept.*

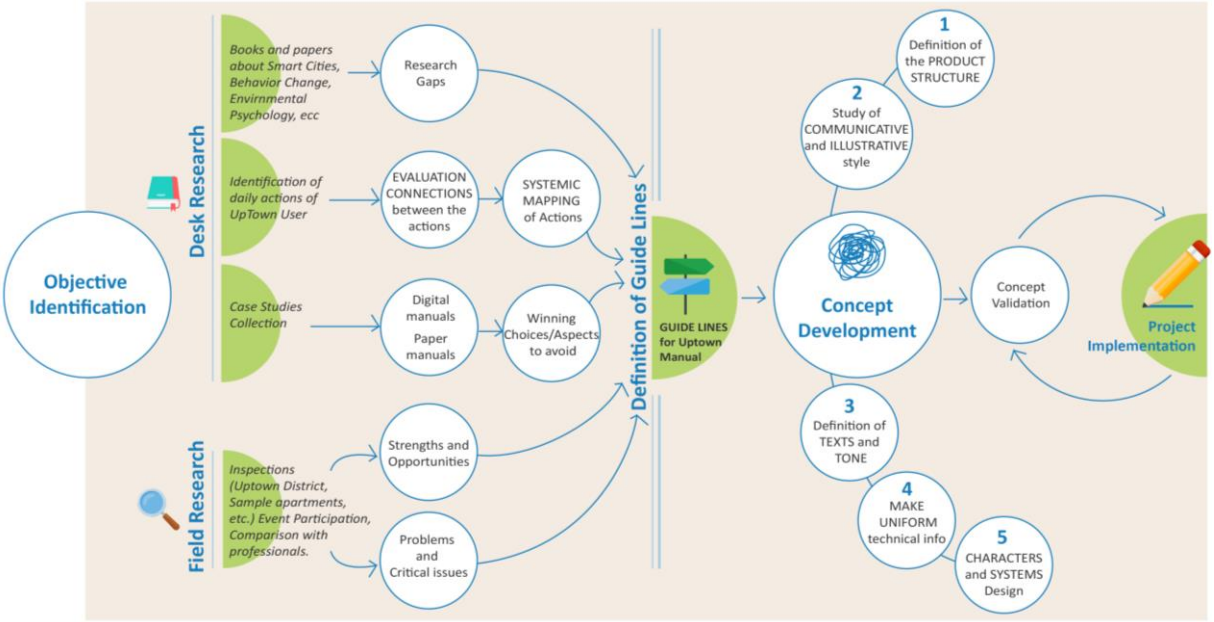

Figure 1. Methodology followed for the design of the Home Handbook. (by Authors)

Throughout the design process, the typical *Systemic Design* approach was adopted, starting with a holistic analysis aimed at understanding even the most complex domestic dynamics, with a view to developing communication that is as clear and complete as possible. This approach, based on the assessment of the relationships between the elements of the system, between the domestic components in this case, assigns extreme value to the properties emerging from them in order to capture the value of the entire organism (Capra, 2014). In this context, further analysis of input and output is fundamental, examining incoming and outgoing material and energy, in order to optimise the use of resources through the re-assessment and reuse of waste in activities other than the original ones. This involves reducing the ecological footprint of domestic actions, through the positive influence of everyday behaviour by users. In keeping with this approach, the analysis involved a territorial reading and consequent action ranging from micro to macro, starting from the apartments and extending to the condominium and then the entire district. The most noble objectives include enhancing the local culture, strengthening the sense of belonging to a territory (Bistagnino, 2011). In this case, dealing with a recently designed space, the adoption of a similar approach would allow the generation of a stronger sense of belonging and community among the residents of the neighbourhood, all of whom have different origins, cultures and backgrounds, giving rise to a lasting form of development and wellbeing.

2.1 Desk Research: from mapping daily actions to analysing existing case studies

Of course, this basic phase involved an initial consultation of the scientific literature on various topics, such as: living, the use of everyday objects, design for behavioural change and sustainability, cognitive ergonomics and environmental psychology. However, in line with the systemic approach adopted throughout the project, an accurate mapping of the

actions[3] (*Figure 2*) that the Uptown user carries out daily was carried out. This analysis examined not only the actions carried out within the individual apartment, but also those carried out in larger shared spaces, such as the condominium, the district, the neighbourhood. This made it possible to trace the relationships between different actions, between actions and specific places and those activities that involve different levels of interaction, collaboration and sharing between users. All actions, while related to one another, were grouped into very flexible categories, such as care, maintenance and cleaning of the home, family management, leisure management and much more.

Figure 2. Mapping of actions and services that characterize the everyday life of the Uptown User. (by Authors)

This was followed by a collection and subsequent analysis of 30 case studies of instruction and user manuals, selected from a wide range of very different contexts. For the sake of simplicity, these cases were divided into 15 paper products (dossiers, brochures, etc.) and 15 digital products (Websites, Applications, Digital Platforms, etc.). This collection initially included an analysis of the scenario in which each individual case was developed, highlighting its main objectives and functions. Subsequently, the main descriptive characteristics were identified, in order to recognize the winning aspects, useful elements for the research in progress, and the critical issues to be avoided for a successful product. One exemplary case study belonging to the category of paper products is the *Maintenance*

[3] The importance of mapping the actions performed by the user in the meta-design phase is highlighted by R.Jurin (Emeritus professor of Environmental and Sustainability Studies, University of Northern Colorado) in his book *Principles of Sustainable Living: A New Vision for Health, Happiness, and Prosperity* (2012). He defines this analysis phase as an indispensable step for a project aimed at inducing a positive and sustainable behavioral change in the users.

Manual of the *US Insurance Agency Bonded Builders Warranty Group*[4] (Florida, USA). The case study greatly simplifies the solving of utility system problems by providing a direct link between domestic problems and the range of possible solutions. It also provides useful information for maintenance by integrating textual insights that guide users through the necessary operations to be carried out and practical tools for monitoring them. In addition to this, it provides essential advice to ensure greater security in the home and provides a glossary to help understand terms that non-professionals may not be familiar with.

Among digital products, on the other hand, the most interesting case in terms of research is that of *Centriq*[5], a Mobile App and Website that allows the user to build a portable library of manuals for all the household products purchased. This is made possible by the camera recognition of the products in question. This gives the user simplified control over the products and quick access to information, anytime, anywhere.

However, most of the assistance services examined envisage solutions related to the individual component or a specific need, without contemplating living as an overall, complete experience. At the end of this analysis, the winning design choices that have increased the functionality and communication of some products and the inadequate aspects that prevented the success of others were identified. The critical points identified include:

- a lack of coordination between content and support,
- excessively technical communication, making it harder for the user to understand,
- a lack of qualitative and motivating instructions and advice for the actions proposed,
- offering content on a single reading level.

The strengths identified and potential ideas for the Home Handbook project, included:

- immediacy of information thanks to graphic representation,
- assistance with carrying out the actions,
- the construction of a story around the contents conveyed,
- details on the operation of the technological equipment,
- the development of communications customised for the individual user.

2.2 Field Research: from on-site inspections to discussions with the professionals involved

A second phase of Field Research involved numerous on-site inspections of the district, particularly inside the show-apartments shown to users at the time of purchase. These inspections allowed an in-depth analysis of the local neighbourhood (services offered, presence of shops, level of security, identification of gathering points) and of the individual domestic environments. As in the case studies, critical elements and potential were identified during this phase of the investigation too. A strong integration between components and

[4] Within the *Maintenance Manual* of *Bonded Builders Warranty Group* (Florida, United States), the resolution of malfunctions is dealt with in column diagrams that highlight the most common problems related to the use of components and potential solutions that can be adopted. Furthermore, for the maintenance actions there is a checklist in which to mark the operations carried out, described in detail in a more in-depth section. Please, see the official websites of the Company: www.bondedbuilders.com

[5] Specifically, the Mobile App of *Centriq* is able to search the required device manual in its library. In addition, it asks the user in which area of the house it is located, in order to categorize all manuals in separate sections for each area of the house. See the official website: www.mycentriq.com

systems was found in the apartments, which provide a coordinated response to user requirements. However, in the absence of specific and clear communication, this interdependence is hard for the end-user to understand.

Extending the analysis to condominium spaces, the presence of common areas and facilities capable of promoting social relations and sharing among residents was significant. However, in order for these spaces to be sufficiently and adequately exploited, it proved desirable to develop communication capable of conveying the values and benefits that can be generated by community life. Finally, by extending the scope of observation to the district, a number of neighbourhood services and meeting places emerged, representing potential poles of attraction for the surrounding areas, which are useful for increasing the interaction between residents and visitors from outside. If enhanced, these places would represent an excellent opportunity for integration and dissemination of the values of the district.

In conclusion, together with these on-site inspections, it was essential to organise individual and collective meetings and brainstorming sessions with designers and partner companies[6], in order to gather and define the information and distinctive aspects to be conveyed and verify, through a constant feedback process, the correctness of the contents developed. During this phase of dialogue and confrontation with other disciplines, particularly with different branches of engineering and economics, the importance of the role of designers as mediators of different languages and backgrounds emerged. The hardest challenge was to minimise the numerous communication obstacles in order to reach a sustainable design compromise, which would take into account different visions and priorities, without affecting the final quality of the work.

2.3 Development of the Project Guidelines

On the basis of these findings, together with the suggestions found within the case studies previously examined, it was possible to draw precise guidelines, essential for outlining the directions of the project. These guidelines can be summarised as follows:

- *extensive accessibility*, design of an immediate and easy to use document, accessible to users with different backgrounds;
- *simplification of technical content*, characterised by a high level of complexity and therefore hard to understand;
- *uniform content*, stylistic standardisation of all the information collected from different construction and technological partners, for the design of a complete and shared solution;
- *different methods of communication*, according to the type of message to be conveyed, e.g. suggestions and educational advice, using humorous storytelling approaches;
- *encouragement of social relations and sharing*, in order to create a sense of community and belonging to a group.

[6] *AI Group, Recchi and Review Spa* (Italy) were consulted for information regarding the building and urban planning of the Uptown Area. The partner suppliers involved are: *Comelit, Cisa, TreP & TrePiù, Itlas, Cott D'Este, Blustyle, Duravit, Villeroy & Boch, Zucchetti & Kos, Grohe (Italy).* These players have supported the creation of the Home Handbook through an accurate and constant sharing of information.

On the basis of the identified guidelines, it was possible to elaborate a first structure of the manual, which was perfected during the whole design phase. Following this step, a parallel study was conducted, focused on communicative, linguistic and illustrative styles, in order to select those that best fit the objectives of the manual. This allowed the homologation of all product sheets, technical data, qualitative information and textual inserts. Finally, functional schemes, explanatory images, infographics and guide characters were developed.

3 The Home Handbook Project

In the same way that objects suggest appropriate actions for their manipulation and use through their physical qualities (Norman, 1988), designed spaces also directly affect the behaviour of users within them (Costa, 2009). Consequently, the design of a domestic space conditions the daily life of the user[7], in the same way that the products inside it can lead the user to repeat behaviours, rituals and choices (Heimstra & McFarling 1974; Lang, 1987; Cassidy, 1997), This strong conditioning power can become a real opportunity, if spaces and everyday objects are used to educate and encourage the user to behave in a virtuous and sustainable way (Fogg, 2005) that could lead to the achievement of a much broader form of wellbeing. The same can be said of behaviour and of the choices to be made when a domestic fault or malfunction occurs. If the product does not inform the user of the correct action to be taken to repair the damage, the next step is usually to consult the instruction manual of the object in question and identify the problem. In more complex cases, the user will tend to turn directly to a specialised professional. Nowadays, with the help provided by the Internet, many users look for different solutions, through dedicated platforms or through the sharing and exchange of experiences and solutions. This mechanism stems from the absence of specific data and useful advice from manufacturers, who often fail to invest as much in the design of a comprehensive and communicative guide to their products as they do in advertising on the market. Therefore, the user can experience feelings of discouragement and disappointment in relation to the object and the space with which it interacts in this scenario. For this reason, the Home Handbook designed by the Politecnico di Torino, wants to offer users the best interaction with their domestic space, with its components and with their everyday objects, encouraging the adoption of sustainable practices, choices and actions for the achievement of individual and collective wellbeing. The Home Handbook is currently designed as a paper tool that every resident of the Uptown district (Milan, Italy) can consult inside their own home. It has been structured in three files (*Figure 3*), according to the three different types of content to be conveyed, but is presented as a single box, to help create a unified idea of the product (*Figure 4*). The project is divided into the following sections:

1. *Welcome Kit*, designed to accompany users as they enter their home for the first time, during the first interaction with their domestic space. It has been conceived as a starter pack, with a set of basic information on the residence, to gain an initial knowledge of the main aspects of the apartment and condominium.

[7] Around 1970 the concept of *Environmental Psychology* began to be explored in a growing way, in terms of the relationship between the behavior of individuals and the surrounding space. In 1997, it will be precisely T.Cassidy in his book *Environmental psychology: Behavior and experience in context to introduce the relationship of direct influence between behavior and designed space (Cassidy, 1997).*

2. *Conscious Living*, designed to help the user to fully understand the operation of the utilities in the residence and the relative components. For this reason, graphic maps have been designed to visually explain the operation of the micro-systems that make up the entire residential system and guarantee a high level of domestic comfort. They are identified in the *Electrical System*, Climate System, Water System and lastly, the Construction System. These illustrations have been extremely useful to communicate extremely complex concepts in a very simple way. Thus, it was possible to guarantee detailed knowledge of one's own home, to a broader range of users, characterized by very different backgrounds. The correct understanding of these systems has become a fundamental goal in further communicating the exact use of domestic components, with the will to simultaneously impart a greater level of awareness of the consumption of resources. The aim is to induce tenants to behave in a virtuous manner, leveraging their knowledge of the environmental, social and economic impact of the actions they carry out daily in their own homes. Consequently, this section is intended to encourage a conscious behavioural change, supported by the knowledge of the benefice of the benefits obtainable (Wendel, 2013) through the adoption of the sustainable principles recommended by the manual.

3. *Your Home*, designed to provide assistance during the use and customisation phases of the spaces. By simplifying and standardising the style of the various technical data sheets of products, furnishing components and finishes, this section aims to facilitate the use of different information on use and maintenance. Also in this case, specific indications aim to suggest the most appropriate actions to the user, those which have the least impact. These instructions not only guide the user to the correct use of the products, but also offer very useful information for the management of numerous aspects of daily life, such as domestic and personal hygiene, waste management, the preparation and consumption of meals and much more.

Figure 3. The three sections of the Home Handbook: Welcome Kit, Conscious Living and Your Home. (by Authors)

In its entirety, the main aim of the project is to guide the user to the spontaneous adoption of sustainable actions and behaviours, providing clear quantitative and qualitative information about the effects and benefits that can be obtained. It is important to note that each individual user will be strongly conditioned by additional factors: firstly, by their sensitivity to the subject of sustainability and current environmental and social challenges, and secondly by the possibility of tracing the behaviour suggested in others, in their neighbours, in their friends and even in the community to which they belong (Fogg, 2005). Although these factors are only partially controllable, the Home Handbook wants to convey a way of life and

living, rich in new and stronger values. Lastly, it aspires to lead users to a considerable level of wellbeing, achieved through the high quality of the social-physical spaces they inhabit (Bonnes and Secchiaroli, 1992; Bonnes and Carrus, 2004). This is why it is essential to preserve the perception of this quality, minimising the frustration caused by complex domestic problems and increasing opportunities for socialising, sharing and exchange in the belonging community[8].

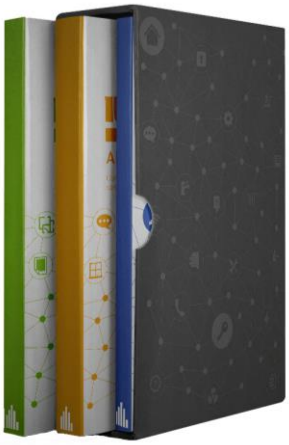

Figure 4. Home Handbook Slipcase designed for delivery to users. (by Authors)

4 A guide to a sustainable and conscious way of living

The Home Handbook project for apartments in the Smart Uptown District goes beyond the traditional single-product handbook model, which is merely theoretical, seldom consulted and consequently of limited use. It interprets the concept of home as a designed space, consisting of a system of connected components. For this reason, it offers users a single tool that helps ensure the correct use of the entire apartment, not only by collecting information about the individual domestic components, but also by describing their interaction. In order to guarantee easier and more pleasant use, an extremely friendly type of communication has been used: in this way, the user is encouraged to consult the manual more frequently. This measure has been adopted to make the product pleasant to read, so users will want to browse through it even during their spare time and not just when dealing with a malfunction. The project conveys content that focuses on achieving behavioural change by including people in the value chain generated, explaining how a sustainable lifestyle can directly affect the levels of comfort and wellbeing within the apartment and the district. Another means of achieving this goal was the inclusion of quantitative data relating to the impact of specific daily actions, highlighting the benefit obtainable by means of alternative virtuous behaviour (*Figure 5*). This made it possible to influence both the management of resources and the social mechanisms to be triggered in the district. This type of content, which is often not included in traditional manuals, could risk being ignored if portrayed with an arrogant and authoritarian tone. Consequently, it was essential to use a friendly language and give advice and suggestions that could encourage the user to perform a spontaneous and conscious

[8] Within the Home Handbook, a tangible example of incentive to share is that of the toolbox for housework. Through a specific in-depth analysis, each resident of the Uptown condominium is invited to share his own tools, in order to create a richer toolbox, available to the whole community. This would not only represent an opportunity for sharing economy, but also a constructive possibility of interaction.

action. The development of guide characters designed according to the type of content that they communicate was extremely useful. Gio, a child who pays attention to environmental sustainability, explains the meaning of content and expressions that revolve around the theme of environmental sustainability today. While Gaia, planet earth, describes a series of bad everyday habits that hinder the maintenance of the ecosystems. Therefore, the project is a complete assistance path that can provide practical help even during the development of small everyday actions and during the resolution of frequent apparently complex problems, which often create doubts and uncertainties in the individual.

Figure 5. The pages of the Conscious Living book. In detail, an example of communicating qualitative and quantitative data to increase the user's level of awareness. On the left, Gio and Gaia, the two leading figures. (by Authors)

Another strength of the Home Handbook was the development of systemic representations, extremely appropriate to facilitate the understanding of the relationships between the devices in the home, the incoming and outgoing flows of material and energy, their quality level[9] and the relationships between actions and components (*Figure 6*). As a whole, the aim of these graphic maps is to explain in an extremely simple way the overall operation of the home system[10] and its specific components, bringing the user closer to the concepts of Circular Economy and environmental sustainability. In this way, the possibility of

[9] The term *quality level* refers to the composition of the resource analysed. This type of information provides specific data about the characteristics of the resources. For example, in the case of the *Water System*, the manual illustrates how the quality of this resource changes according to the use made of it. It also provides useful information for the potential re-use of waste water, thus avoiding direct disposal in the sewer system.

[10] The effort to communicate the connections between a designed space and all of its features through a visual representation was also highlighted in the *Three material stories* project by the architect Lindsey Wikstrom, located in the *Broken Nature Exhibition* at the *Milan Triennial (1st March - 1st September, 2019. Curator: Paola Antonelli).* The project enhances all the visible and invisible agents of architecture which should be understood in relation to each other, thus overcoming the mere architectural representation in scale.

encouraging users to adopt sustainable behaviour is strengthened, by increasing awareness of the relationships between input and output within their living space.

Figure 6. The pages of the Conscious Living book. In detail, an example of systemic representation aimed at communicating the Plumbing System in an Uptown Residence. (by Authors)

Nowadays, entire communities are called upon to respond to impending major environmental challenges, but it is extremely difficult to achieve a daily behavioural change if individuals do not have tangible evidence of the impact of their behaviour within the place where they live (Davico, 2004). Consequently, providing this type of information would lead the user to perceive the extent of the problem more clearly, encouraging him to employ resources and energy to reduce or solve them (Camagni, 1996). Communicating the value of the Circular Economy and the potential still inherent in domestic outputs in a Home Handbook (*Figure 7*) becomes an element of fundamental importance to guide tenants in the district not only to the use of the spaces available but also, and above all, to a form of living that respects the environment and the community.
We are talking about a more extended and lasting form of wellbeing that starts with the individual and is subsequently triggered in the whole community. This is not just about domestic wellbeing but also, and above all, about social wellbeing, which makes the Uptown tenant part of a close-knit community that shares values and lifestyles. So the Uptown Home Handbook wants to suggest a conscious view of life and living, making the community more aware of the alternatives to an often short-sighted and high-impact way of living.

Figure 7. The pages of the Your Home book. In detail, the representation of the consequences and benefits generated by the different waste disposal methods chosen by the user. (by Authors)

5 Conclusion

The Home Handbook has been designed to be delivered when buying an apartment in the Uptown district (Milan, Italy), and particularly to accompany tenants throughout their lives inside the house. The first delivery of the product will take place in July 2019, after which it will be possible to gather useful feedback from the tenants. This operation will allow the implementation of targeted changes and useful product upgrades, in anticipation of further dissemination within the new residential complexes being built within the smart district. Originally conceived in paper format, to be present in all living spaces, it is now undergoing further digital development. The goal for the future is to digitally provide key content within a specific section of the Uptown mobile application. This new result would allow residents to consult the handbook at any time and in any place using their smartphone. The general aim is to achieve an increase in the level of engagement by using additional communication tools, such as videos and animated images, the possibility to engage in dialogue with other members of the community through exchange and sharing groups, providing real-time notification of actions to be taken and not to be forgotten and integration with the automated elements in the house. Nowadays, designers have much more responsibility: the design of products, services and systems has to fulfil an additional and more important task, which is to lead the user to adopt a more sustainable lifestyle, not only for living ecosystems, but also for the society in which they live. The purpose of this article is to lead the design community to explore the potential of a long-term domestic assistance project as an aid, a guide and, above all, a daily educational tool that can lead the residents of a place to become aware inhabitants and decision-makers, thereby improving their daily life and, above all, fostering harmony with the environment that nourishes and sustains mankind.

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Textiles & Biodegradability: Challenges and Opportunities of sustainable textile Futures

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The move towards circular economy seems like a necessity nowadays. Why not apply the processes of nature? Biodegradability is a material characteristic, which is necessary for closing the biological cycle. If biodegradability was a new and invisible criterion for textile and fashion design, how do we design and manufacture such textile products, which are biodegradable? Very few scientific publications are found on biodegradability of textile products. In fact, formerly textiles have been biodegradable but the contemporary textile industry has unlearnt how to manufacture them and customers have unlearnt how it feels to wear such garments. An applied research collaboration between University and Industry enabled a research team to work in an interdisciplinary setting on developing answers to this novel kind of question.
This paper aims at sharing experiences related to biodegradable textiles along with its scientific testing results as well as the textile design research. The combination of both perspectives allows a multifaceted critical reflection on how the concept of biodegradability could lead to sustainable textile futures.

Keywords: biodegradability, textile design, sustainable textiles, circular textile future, 4th order of design

1 Introduction

Biodegradability is a material characteristic, which is necessary for closing the biological cycle. Via composting, biodegradable materials decompose and reintegrate into the natural environment. This urban recycling process is used for plants and food waste. Is it also applicable for textiles? From the point of view of the consumer, composting is a meaningful action, natural wastes are returned to nature and help grow new natural resources – sometimes, this even happens in their own garden. In a cradle to cradle concept, this route represents the biological cycle (Braungart, 2003). Would it be equally meaningful for the customer, to compost their cotton jeans? Yes indeed, was the answer from the Swiss design company Freitag lab.AG, known for their bags made from recycled polypropylene tarpaulin from trucks. In a joint research project with Lucerne University of Applied Sciences and Arts the concept of biodegradability was addressed with a completely new approach for textile and product design as well as the supply chain.

However, during the project, biodegradability became more of a concept for sustainable textile and product design, than just the last step in the life cycle. It was not about the recycling process anymore, but biodegradability became a product design criterion itself. The research question reads: “How do we design and manufacture a textile product, which is biodegradable?” The decision to design for a biological cycle affects the design process: the choice of materials, the composition of materials, the applied dyes, the applied processes, the making-up, the product communication, the use phase and the end-of-life treatment. Other than the design processes, the company wanted to know, if biodegradable textiles are more sustainable than conventional textiles.

2 Motivation

The move towards circular economy (MacArthur, 2013) seems like a necessity nowadays. Especially the textile sector is characterized by over-production, which results in high quantities of waste, by globalized processes, which result in poor communication and lack of transparency. This makes it difficult for all parties involved to know how the textile materials and products are manufactured, processed and designed. Nevertheless, the UN makes clear, that action is required to lower the carbon dioxide production, e.g. by lowering the amount of fossil energy consumed (Global Climate Action Summit, 2018) and ultimately by more efficiency in production and less consumption world-wide. Therefore, and for reasons of resource depletion, research in this field is needed in order to show alternative ways for sustainable production and consumption.

This paper aims to share experiences related to biodegradable textiles from a study along with its scientific testing results as well as the textile design research. The combination of both perspectives allows a multifaceted critical reflection on how the concept of biodegradability could lead to sustainable textile futures.

This includes thoughts on how the concept of biodegradable textiles as a design criterion does reframe the role of a designer and re-distribute the question of responsibility within the value-added chain. This analysis is performed from two perspectives: the one of the natural scientist and the other of the textile designer. The natural scientist analyses and interprets testing data from the biodegradability tests. The designer uses the criteria derived from the interpretation of the tests and applies them as design criteria for the textile product development process. The two perspectives are interlinked by the common vision of a circular economy and, in this case, closing the loop by a biological cycle, and the proof, that the products are biodegradable. Therefore, the end of the product defines the beginning, meaning that the product design has to meet the requirements of the clients as well as fit into nature’s cycles.

2.1 Case-Study F-ABRIC

The FREITAG lab.AG company started several years ago to add to their bag collection under the name of F-ABRIC a range of textile products such as basic garments and bags. The concept for this collection was one of regionalism and biodegradability. Regionalism was provided by defining a certain perimeter around their company location and stating, that all processes and resources should be located within this perimeter, which was defined by 1000 km. Biodegradability was defined as a goal for sustainability and a vision, that the textiles would be readily absorbed by nature after their use phase. The research project was funded by Innosuisse, the Federal commission of technology and innovation in Switzerland. The research project includes several phases: the testing of biodegradability, the scientific

evaluation of the sustainability, material sourcing, material experimentation, user-centered textile and product design.

2.2 Biodegradability of F-ABRIC Textiles

Very few scientific publications are found on biodegradability of textile products. Also, textile materials are not provided with biodegradability data; textile chemicals however include this information in the safety data sheets. The testing of three textile garments from the F-ABRIC collection provided the scientific data on biodegradability for this study. The Hohenstein Institute in Germany offers a standardized biodegradability test for textiles (Din EN ISO 11721-2).

Product	Color	Composition
Bag	dark grey	100% linen, coated
Denim Jeans	blue	81% linen, 19% hemp lining: 51% modal, 49% linen
T-Shirt	black	75% modal, 15% linen, 10% hemp

Table 1: Tested garments for biodegradability.

The experimental design included the testing of three products, see table 1. The experiments are carried out in the environment employing three standardized soil compartments. The textiles are inserted in the compartment and excavated six months later. The test results are the following: weight loss after six months in the ground, indicating how much material has been decomposed; eco-toxicity tests on the soil and living creatures surrounding the objects, indicating if there are toxic or harmful reactions; as well as a visual test to assess the qualitative process of decomposition.

Product	Percentage of weight loss
Bag	61,56 %
Denim Jeans	89,83 %
T-Shirt	87,74%

Table 2: Results of weight loss by biodegradation for the three products (Hohenstein, 2016).

The highest loss of weight results show the denim jeans. This shows that the denim jeans are nearly completely biodegradable within six months. The bag in contrast, is only partly biodegraded within this period of time. The black T-Shirt has also a high biodegradability.

The ecotoxicity tests were carried out with seedling growth test and earthworm toxicity tests. The results lead to the following conclusion: the ecotoxicity is very low. However, slightly elevated values of copper and nickel were found.

Figure 1: Visual test on denim jeans before and after biodegradability testing (Hohenstein, 2016)

The visual test results for the decomposition process in figure 1 show that the denim jeans is nearly decomposed, as concluded earlier. The remaining material portions are located at the seams.

The results are interpreted and connected to a specific design step, which has to be revised for the design of biodegradable textiles. The textile fibre is biodegradable as expected because natural fibres were used both mixed and non-mixed. Even synthetic fibres originating from natural cellulose material, like modal, do not disturb the biodegradation process.

The textile technique (spinning, weaving, knitting) and the mass per unit area do not seem to have a relevant influence on the decomposition process of the products. It would have seemed logical to conclude, that a tight woven and heavy pair of denim trousers would need more time to degrade than a knitted light T-Shirt. However, the results show that both products biodegrade equally fast in the given testing time.

However, the finishing processes and chemicals are relevant to the biodegradation. The bag, which has the lowest biodegradability value, did have a coating. The heavy metal values of all three products were slightly elevated because of dyes containing heavy metals. It is important to check the safety data sheets for biodegradability and ecotoxicity test results for all chemicals used.

The making-up process is relevant for the biodegrading process. Where double or triple layers are sewn, the biodegrading process is inhibited. The bag had multiple layers for interior bags, which resulted in a slower degradation. In addition, the sewing yarn is not made of natural materials and therefore is not easily biodegradable. The bag had metal buttons, which were not biodegradable.

2.3 Ecological Analysis of biodegradable Textiles

For the evaluation of the ecology of biodegradable textiles, different methods were compared, mainly cradle to cradle, life cycle assessment (LCA) and simplified LCA. The difference between cradle to cradle (C2C, Braungart, 2003) and LCA is analyzed and discussed in the Position Paper of NL Ministry of Infrastructure and the Environment (NL Agency Ministry of Infrastructure and the Environment, 2011). The focus of C2C is on biological and technical cycles. Biodegradable textiles fit into the biological cycle. This product could be certified by EPEA as a C2C product (EPEA, 2013). The certification includes the suppliers in the whole supply chain. This makes it less feasible and very costly for this project. The simplified LCA provided some insight on the matter. However, the LCA does not show any special benefit of biodegrading. This is due to the fact, that the LCA is a cradle to grave analysis and C2C a cradle to cradle analysis. The CO2 generated by different end of pipe measures (including composting) does not vary; therefore, the LCA results do not show any difference in applying different end-of-pipe technologies. The ecological benefit lies in the production phase, where natural materials and sustainable processes are chosen in order to allow for biodegradability.

The LCA showed, that in production for biological cycle products, there were less chemicals used than in traditional products and therefore fewer emissions to air and water were generated (internal report HSLU, 2016). The production phase only accounts for less than half of the ecological burden in the entire life cycle of a textile. The use phase causes a higher ecological effect through water and energy use as well as detergent use than the

production phase. Considering sustainable textiles and not just biodegradable textiles, the aspect of the use phase has to be included in the considerations.

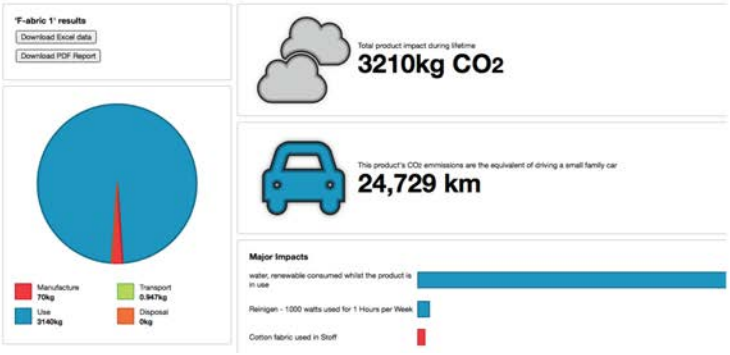

Figure 2: Result of simplified LCA with LCA Calculator of Denim Jeans

2.4 Findings from a scientific Point of View

The biodegradable testing has shown, that biodegradation of textile products is possible under ideal conditions. It has also shown, that decisions on every step in the textile design and in the production process need to be made, in order to foster biodegradation. The most important decision is on the material used: a biological / natural textile raw material. The applied chemicals and the finishing process influence the degrading process and the ecotoxicity to plants and animals. Of high importance is the design of the garment. Multiple layers, which are sewn together and non-degradable accessories inhibit the decomposition of the product. In order to create a biological cycle product, the design phase of the product is the primary issue – it decides, if the product will be biodegradable later.

For the biological cycle to be complete, the composting process needs to be standardized and industrialized in order to foster a fast degradation. However, by focusing design only on biodegradation, important environmental issues are excluded. The process emissions during production as well as the emissions during the use phase need to be taken into account, for they account for more than half of the life cycle emissions of textiles. Therefore, the choice of production processes and the use phase have to be taken into account additionally. In order to be sustainable, the product needs to be designed for a low emission use phase, for instance by giving advice on low emission cleaning, drying processes and on ecological detergents.

3 Research Textile Design Part

In addition to the criteria defined by biodegradability (see section 2), criteria have been formulated with the industry partner, which should be fulfilled within a design context. In terms of comfort, look & feel, the products must be comparable to existing products and meet at least their standards. In addition to that, the products are supposed to embody the circular principle because they are biodegradable.

Therefore, and at any stage of the fabric and product development, both scientific and design criteria need to be considered. Both standards are of equal importance and the goal is to achieve results being satisfactory for both perspectives.

Here the research procedure is described in three phases including development of a design vision, the extensive material experimentation and the user-centered product design process.

3.1 Design Vision Biodegradability

The research process (Weber et al., 2014) was initiated with the description of a design vision which is a framework illustrated in a conceptual and visual way:
The conceptual framework results from workshops between the industry partner and the institutional researchers. The workshop participants identified attributes which provide a garment's wearing comfort and put all of them in an order indicating from top to bottom their priority in favour of the purchase of a garment. On the left side, the framework points out comfort-giving functionalities of garments. On the right side, it lists details of construction and making-up as well as fabric properties, which may be useful to meet the expected performance and fit of the products (Fig. 3).
The visual framework results from a study on how comfort has been achieved in garments and workwear before the invention of the synthetic and elastic fibres. From the 1950s onwards until today, synthetic fibres are blended with natural fibres in order to introduce additional functions in the textile constructions, for instance elasticity. This has influenced fashion development in a way that the silhouettes could become much more body fit while still offering wearing comfort by the help of stretchable fabrics.

Formerly, the need to provide free movement without the use of non-natural synthetic fibres has led to creative solutions. This research provided helpful insights on how this was accomplished: Pleats, folded details or the design of loose silhouettes with integrated mechanical straps or buttons to adjust the fit would lead to elaborately engineered garments. With a collection of selected images illustrating historical and functional features, a variety of such examples could be documented for the use in the design process. This visual research will help to understand how volume can be generated and removed in a garment with an inelastic fabric consisting of 100% natural fibres. In addition, this historic observation is the key to re-introduce natural functionality and comfort to the customer who has unlearnt how garments without stretch ability do look and feel (Fig. 4).

DNA F-ABRIC for woven and knitted material

Functionality → Task	**Solution → Job**
	Construction
aesthetics	widen / narrow
fit	open / close
silhouette	shorten / lengthen
freedom of Movement	insert / take out
longevity	
changeability/ variability	
modularity	***Material property***
thermos control	course / fine
weather protection	warm / cool
additional benefits	plain / structured
	elastic / stiff
	heavy / light
	durable / fragile

Figure 3: conceptual framework design vision of biodegradable textile products

Figure 4: visual framework design vision functionality of biodegradable textile products

3.2 Material & Finishing

The challenge here is to fulfill both scientific and design criteria. From a design point of view, textiles and products should have a specific product expression reflecting the sustainable conceptual framework of biodegradability which was followed in the process. Designers might not be convinced that a single jersey or a plain weave fabric is suitable to convey the sustainability of a range of garments. Therefore, material experiments in weaving, knitting and finishing were conducted to achieve functionality such as softness, pleasing touch along with strength and durability. At the same time, satisfying aesthetic criteria were discovered in terms of complex textile designs including vivid surface constructions and multi-coloured details challenging the future customer.
The results of the experiments were examined and evaluated in expert teams from University and industry in order to identify, which samples would embody both the scientific and design criteria. The selected samples do well balance both objectives including invisible and visible aspects (see Section 4).

To give an example the woven structures are made of yarn-dyed warp and weft and are woven into three dimensional structures, which are mechanically stretchable (Fig. 5). The colours melt into each other as a faux-uni, but seen at close range, they are multicoloured. As a material itself it is just another textile design. But considering it within the larger sustainable conceptual framework of biodegradability, it represents a great depth of design (Huwiler, 2018) with a potential to shift the linear textile industry towards circular economy.

Figure 5: selection of sustainable biodegradable textiles (Knit, Woven)

3.3 Product & Usability

The experience of the FREITAG Lab.AG company in promoting biodegradable clothes clearly indicates that the consumer is not willing to make any compromises in favour of sustainability. This means that the product expectations towards sustainable products are in general remaining the same. Only if a garment is satisfying in terms of the look and feel, the customer will take a purchase into consideration. Customers nowadays are used to narrow silhouettes based on a body fit product. To integrate the expected level of comfort, customers are used to having materials that are stretchable, therefore partially consisting of elastane fibres. The sustainable, conceptual framework of biodegradability is contradictory to the use of additional synthetic fibres to create comfortable fabrics. Therefore, the product design needs to overcome this challenge by finding creative solutions as mentioned before.

The only probable approach to successfully introduce circular textiles and fashion into the market, is to make the invisible aspects explicit. The product communication needs to include all information regarding the circular quality of the product. Moreover, it should point out in which phase of the circle and which stakeholder has the lead in performing circularly in order to activate the sustainable potential of the product.

3.4 Findings from a Textile Design Point of View

For the development of biodegradable textiles, the following criteria are formulated, which integrate scientific and design aspects and represent an integral part of the sustainable conceptual framework of biodegradability:

- Composition: 100% natural fibres or synthetic fibers based on cellulose
- Yarn diameter: there is a limitation to fineness of yarns made of natural fibres which cannot be compared to the same of synthetic fibres
- Fabric weight and Durability: the heavier the fabric the longer the biodegradable process takes, the lighter the fabric weight, the less durable the material and garment will be
- Industrial production in weaving and knitting must take into account that the yarns are of natural strength and flexibility which sometimes requires adjustment of production speed
- Material comfort: Softness has to be achieved through surface construction
- Complex textile design: the enhancement of single jersey and plain weave into more elaborate surface design requires jacquard skills along with the appropriate industrial machinery in production
- Dynamic Colour: in the best case make the weak property, such as the fading out over time due to weak fastness to colour, can be a key topic of the design transforming the ephemeral colour quality into a strength, inviting the customer to discover overtime changing stages of the dynamic colour (Müggler Zumstein, 2018)
- Colour and Finishing: dying and printing can only include biodegradable chemicals
- Plant based finishing: the processing must avoid metal-based chemicals
- Garment pattern making: the inclusion of several layers of fabric is extending the process of biodegrading in terms of time required.
- Garment silhouettes: the more the silhouettes are fitted to the body, the more the non-stretchable character of the fabric needs to be compensated with functional details providing the required width for the body movements
- Communicate to the customer the circular properties of the textile product

- Explain how the user can take responsible action in extending the use of it as long as possible
- Encourage to create a regional network of services, touch points and places where information at any time can be accessed how to close the cycle by initiating the composting process
- Take responsibility as a designer for the on-going change in the market which means that in the transition from linear to circular, all stakeholders involved become partners envisioning the common goal to perform the circle which cannot be an individual mission

4 Critical Discussion referring to Design Theory

The observation that in the last fifty years the textile and fashion industry has become a non-transparent, complex and quite harmful economy for our society and the environment requires a critical reflection on design theory in order to create a better understanding and develop a novel vision.

Reflections on ecological design for sustainable futures have been mentioned almost 40 years ago. This knowledge has led to the movements and results in product design at the end of the last century (Tischner, 2003). Unfortunately, it has not yet conquered and shaped the world of textiles and fashion. More than ever it is therefore crucial, to review those statements from a today's point of view, to finally rediscover their sustainable impact and to substantially learn from it. A closer examination will probably allow to conclude, why it is so difficult to implement ecological aspects into textile industry.

In the seventies, "criteria for a new design" were mentioned (Burckhardt, 1977) and within those Burckhardt was initiating the discussion about the fact that the quality of design cannot only be described by formal and technological aspects but rather by shifts from the product itself to more process-related questions such as: "is [the product] made from raw materials sourced without oppressing anyone? was [the product] manufactured in meaningful, non-rationalized labour processes? is [the product] multi-purpose and is it built-to-last? in what state is it discarded and what becomes of it then?" (Burckhardt, 1977)

These questions redefine the designer's responsibility. In addition, it extends the understanding and definition of design which at that time already had been established. However, let us feature here what Burckhardt in addition in the eighties mentioned (Burckhardt, 1980). He described the invisible aspects of design. As he stated, the so-called invisible design includes today's and tomorrow's worlds, consisting not only of objects but as well as of interpersonal relationships.

If this perception of design is valid today and onwards, it is no longer possible not to include the user in the design process, not to know who has manufactured the product, whose hands have prepared the production machines for the translation of raw-materials into products, etc. By that, the responsibility of a designer and of all stakeholders in the process is redefined. The so far mainly aesthetic approach has shifted to a multifaceted understanding of design quality, which includes ecological, social and economic criteria.

Later on, in the nineties, Jonas (Jonas, 1994) clearly points out key criteria for ecological design such as "longevity, repair-friendliness, the ability to disassemble the product as well as to easily separate materials from each other, reusability and recyclability". Furthermore,

he explains, that these aspects may for the consumer usually be of secondary importance as the products first need to fulfill aesthetic expectations. Nevertheless, the sum of all aspects do make explicit what the values of sustainable products in any case should embody.

To perform sustainable development at the intersection of fashion and textiles, we need to understand the limitations of design (Braungart, 2003), build networks to collaborate and pair with partner disciplines of design (Jonas, 1994), reframe the role of the designer (Hornbuckle, 2018) to be able to overcome the challenges involved. Hornbuckle describes how textile knowledge “can drive and direct innovation towards circularity” (Hornbuckle, 2018). Product communication is becoming increasingly important as invisible aspects such as sustainable impact of textile products, do need further explanation to the customer. Let us give an example here. The sustainable denim product may look similar to ordinary trousers but in comparison the product price of the sustainable one would be slightly higher. In order to highlight the invisible value, a specific communication along with the product is required to reveal the difference between ordinary and sustainably designed textile products.

“Value of textile design knowledge needs to be effectively applied along with a set of non-textile but in general important skills, such as interdisciplinary communication with stakeholders within the process, organization and management skills, creative information visualization tools.” (Hornbuckle, 2018)

5 Reframing of the Designer’s Role

Nevertheless, various approaches have been manifested already suggesting probable solutions to introduce sustainable change within our harmful textile and fashion industry. With the urgency given, the textiles and fashion industry need to be reframed within a larger context. This means that change towards a circular future can only happen if design thinking is prepared to address the complexity of the fourth order of design (Buchanan, 1992). Support is given by more closely and internationally linking research in the field with the entrepreneurial players through consultancy and knowledge sharing (Black, 2008) (Gwilt, Rissanen, 2011). By anachronistically integrating existing knowledge and finally turning thoughts into actions, our environment, health and wellbeing can be affected positively through the sustainable conceptual framework of biodegradability.

Combining the insights from theory together and the outcomes of the research project, the following setting could be developed to answer the research question how to design and manufacture a textile product, which is biodegradable. In general, it has to become a regular design practice to make all invisible aspects in product design and presentation accessible for everybody. In particular, design can therefore be used to enhance our lives and environments if the design process for textile products does include the following criteria together with the criteria mentioned in section 3.2) these conditions represent the so-called sustainable conceptual framework of biodegradability:

- Collaboration of scientists together with designers
- use design skills to make an interdisciplinary setting of work productive
- understand the need to communicate visible and invisible aspects of design
- design user-centered but extend the awareness to all stakeholders involved
- become network partners with a common goal to perform the circle by the help of each other

- think in various dynamic rhythms and interconnecting them while designing in favour of circular textile future

“But equally there are examples of all speeds in the natural world which point towards positive and expansive examples of the full spectrum from fast to slow in other industries, for example food and architecture.” (Goldsworthy, 2018)

6 Conclusion & Outlook

From the natural scientists’ perspective, the results of the biodegradation tests can only generate meaning, if they are contextualized with the material properties, the textile and design processes. By contextualizing the biodegrading results with design and technical knowledge, meaningful insights are gained on how certain parameters and decisions influence the sustainability of a product. In fact, by applying a reverse engineering approach and starting at the end-of-life stage of the product, the connection form grave to cradle could be made. If the product characteristics of the product for a specific grave design is understood, the grave can be transformed into the cradle and the circular perspective appears.

From a design perspective an over-all design approach is required to be able to include the various scientific and visible, as well as invisible aspects in the design process. The sustainable conceptual framework of biodegradability can serve as a guideline in a textile product development process. Of course, this concept can be linked with already existing sustainable approaches from pioneers such as for example the idea of reducing waste in production (Rissanen, 2013) or the focus on the dynamic and process-oriented character of product-user relations (Fletcher, 2016).

By connecting design with sustainability, a unique meaning is introduced into the product, which makes it both desirable to the customer and leads to less substitution products and ultimately to less consumption (Walker, 2006).

The concept of shared responsibilities in a circular textile future remains theory, unless the understanding and awareness of the textile cycle including transition of stages from use to composting can be learnt through personal experience. However, it will take common efforts to change the perception not only from the customer but also from all stakeholders involved from linear to circular (Circular Transitions, 2016).

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Trigger Design Circles: A Behavioral Design Strategy to Practice Desired Behaviors

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Why do people often fail to practice what they have planned in eveyday life? It is because daily habits are hard to break. Unless special events take place, people tend to stay in circles of habits although they know new behaviors beneft their lives. Purpose of this study is to develop a behavioral design strategy that builds a natural path to prolong one's desired behavior with a set of triggers. By setting pleasure to trigger actions upon users' free will, it is different from other behavioral design approaches. The paper suggests nine pleasure triggers based on behavioral sciences, and categorized from pleasure in game theory into *anticipation, sensation, possibility, competition, self-identity, unexpected, socializing, control,* and *triumph & pride*. The paper proposes Trigger Design Circles as a design framework to analyze action paths that people repeatedly choose to do. With the circles, designers could from develop and evaluate concepts using nine triggers as inspirational tools.

Keywords: trigger design; pleasure; nudge; behavioral design strategy; user-centered design

1 Introduction

Everyone knows regular exercising is a better choice for health than watching YouTube. Then, why is it so hard to keep up with exercising, while subscribing YouTube channel so easy? Are there secrets for desired behaviors that last? This study started from this question.

Nudge is one of the prominent behavioral economics interventions using indirect and positive reinforcement to affect one's decision-making. Most of *nudge* researches and experiments are focused on making policies and sales increase in which people choose their actions under influence of planners' intention. Hence, *nudge* approaches for the benefit of public or private shows different needs from those of individuals. Therefore, it could dissatisfy users. Accordingly, with *nudge*, people often fail to maintain their behaviours although they acknowledge it is a good choice for themselves and public. For example, we register for a yearly health club membership in January enticed by a fancy advertisement that supports our new year's resolution, but often fail to go longer than three months.

Therefore, this study brings out the necessity of design study on behaviors that last which can be propelled by the user-centered perspectives. To initiate this research, we

investigated behavior trigger design model with key terms by referring prior studies on human behaviors: BJ Fogg Behavior Model (Fogg, 2009), Habit-Goal Interface Model (Wood & Neal, 2007), Brains, Behavior & Design Toolkit (IIT, 2011), Game theory (Schell, 2010; Walsh, 2010) and 'flow' theory (Csikszentmihalyi, 1990). We hope this study helps designers to ideate concepts naturally come along with people's daily choices, and as a result, achieve its continuity.

2 Design Elements

This article introduces two main design elements for a behavioral design strategy to practice desired behaviors that last.

2.1 A Set of Triggers

According to Fogg (2009), trigger "causes someone to perform a target behavior." He changes his term to *prompt* since 2018, meaning "to do it now." However, in this paper, trigger will be used because we would like to emphasize it as an external device that can be developed as a design concept. Below are three noticeable features of trigger we suggest in our study.

1. It is a designed device as part of a product, service, or system.
2. It directs one's behavior toward desired one that is difficult to practice.
3. It is not a single fixed trigger, but a set of responding triggers to a user's current conditions including obstacles.

In the Fogg Behavior Model (2009) as seen in fig.1, there are three types of triggers*:* *facilitator, spark,* and *signal* based on motivation and ability trade-offs of a user. For example, if a user's ability is low and motivation is high, *facilitator* triggers the action; if ability is high and motivation is low, the *spark* does; if both are high, *signal* works. In this model, to increase users' motivation and ability is the core value, because otherwise, no actions will occur even it is stimulated with triggers.

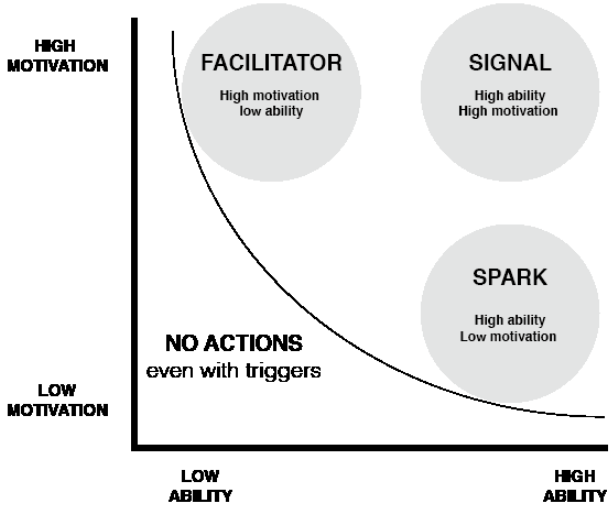

Figure 1. Fogg Behavior Model (2006)

Studying the Fogg's types of triggers, we discovered that the trigger should be designed according to a user's condition in order to encourage one's action. Various types of triggers are designed for a single product to be used by people. Take a look at YouTube. As shown in fig.2, it entices users with several triggers embedded in its system so they could instantly visit and always watch its videos. First, it sends you an alarm (trigger A) when there is an update on your subscribed channel (user's condition A). Second, after you watch a video, it suggests a new video (trigger B) based on your previous choices (user's condition B). Third, other viewers' preferences influence your choice of a video (trigger C), views (trigger D) on a video and other viewers' comments (trigger E). With all these different triggers timely applied to a user's choice, YouTube regularly engages users to keep coming back to its service.

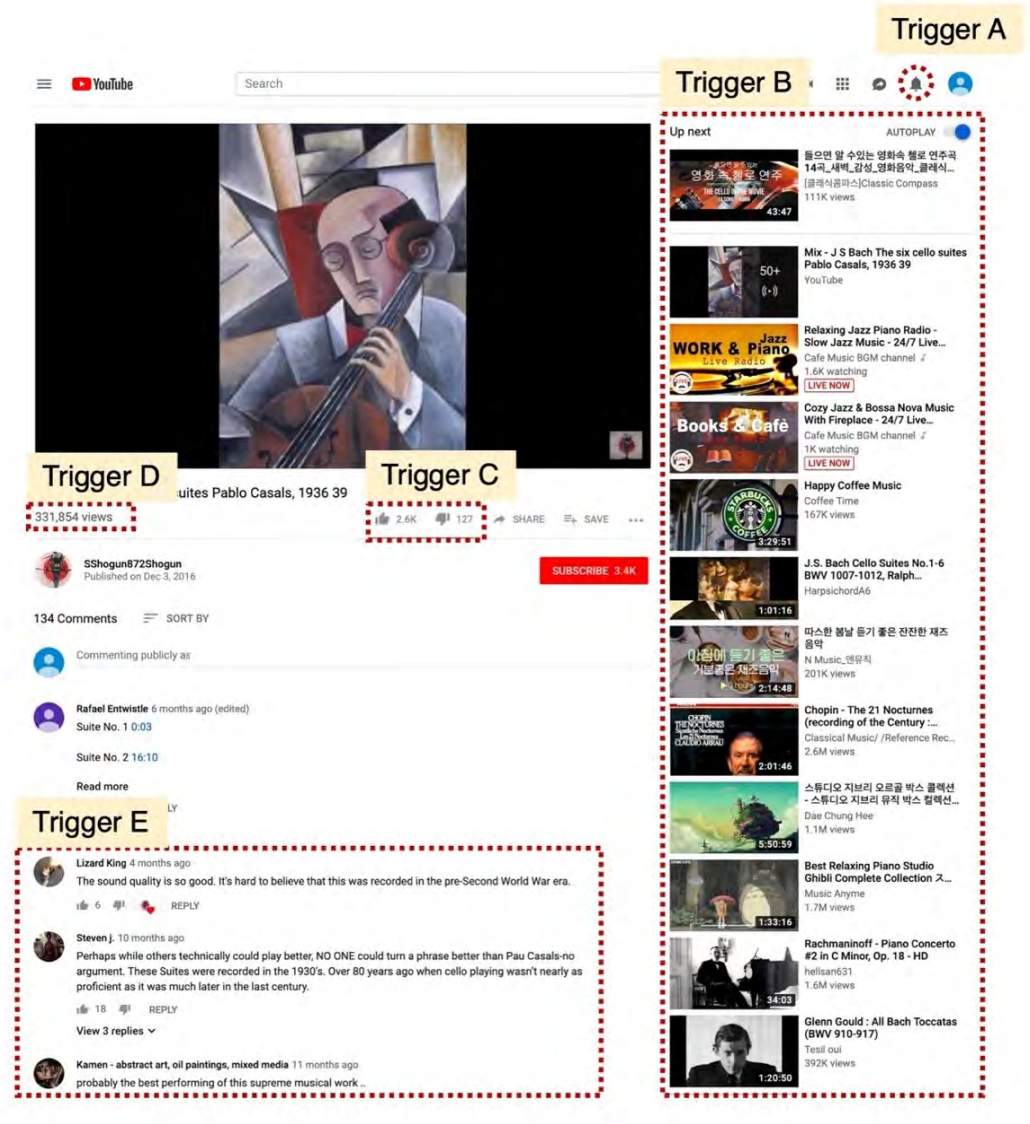

Figure 2. Youtube's various triggers played based on a user's condition

We learned from the case of YouTube that popular social network services or mobile applications successfully applied triggers as important design elements while delivering pleasurable experiences as they brought up heavy users. As Wood & Neal (2007) put it, a user's goal does not always lead one's habit because the habit is interfered by "performance location, preceding actions in sequence, and particular people." Thus, it is vital to consider

the user's performance contexts and avoid to associate it with undesired ones. As a result, design trigger with ‘proper' feedback on time and contexts become a crucial element to develop a lasting behavioral design strategy.

2.2 Factors of Pleasurable Experiences

In this study, pleasure is not a hedonic emotion, but a fulfilled and powered emotion to move oneself forward. Plutchik (2003) claims that emotions are not just subjective feelings, but mechanisms that have evolved during the processes directly linked to the survival of humankind. Based on this claim, pleasure, as a condition of human survival, differentiates our approach from a single *nudge* focusing on loss and gain mechanisms. We believe pleasure is the strongest emotion of all to elicits actions upon one’s free will. Through fear and anger you can initiate people to act, but shift them to positive feeling is more important to trigger behaviors to last. Therefore, pleasure is be the key strategy.

3 Design Triggers with Pleasure

We studied Brains, Behaviors & Design (Cervantes et al., 2011) and game theory (Leblanc et al., 2004; Schell, 2010; Walsh et al.,2010) in which players are engaged with pleasurable experiences. Based on these studies, we were able to have foundation for pleasure triggers.

3.1 Triggers from Brains, Behaviors & Design (BBD) Toolkit

There are five tools in the toolkit: *Reference Cards, Concept Ecosystem Poster, Irrational Situation Guides, Strategy Cards,* and *Loss/Gain Worksheet*. To analyze its structure for our purpose, we categorized them into three parts (fig. 3). *Reference Cards* is the library for this toolkit and connected with *Strategy Cards* that gives actual suggestions to designers. We used *Irrational Situation Guides* as a reference point to get ideas for triggers because it explains their applications in practices. *Loss/ Gain Worksheet* was least considered for this article as the tool is not directly related to pleasure but financial losses and gains.

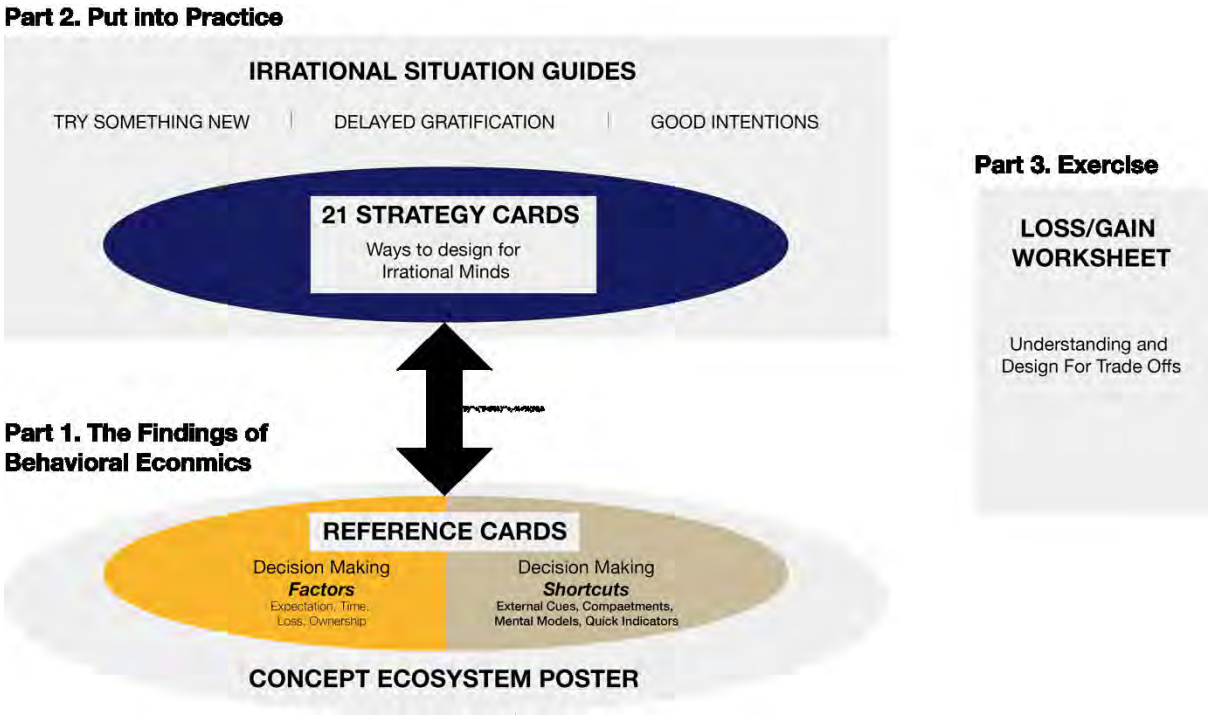

Figure 3. Structural Analysis of Brains, Behaviors & Design (IIT, 2010) Toolkit

As a result of studying this toolkit, especially *Strategy Cards* based on *Irrational Situation Guides*, we discovered that behavior requires triggers either to initiate and strengthen it.

Table 1. 13 Possible Triggers from 21 Strategy Cards

Initiating Triggers	
#9	Highlight colorful and personal stories.
#14	Set up positive expectations.
#19	Provide opportunities for people to pre-commit.
Strengthening Triggers	
#5	Break up large gains into smaller gains.
#6	Conjure up positive memories of similar experiences.
#7	Associate new behavior with an existing routine.
#8	Draw upon or introduce relevant social norms.
#12	Align the desired outcome with the user's identity.
#13	Introduce ownership.
#15	Use surprise to make gains more pleasurable.
#16	Minimize risk associated with the desired Behavior.
#17	Use facts to lend credibility and memorability.
#18	Give the user frequent feedback about the consequences of their actions.

Out of 21 *Strategy Cards* of BBD toolkit, we were able to derive three behavior initiators and ten strengthening factors. Many studies in behavioral psychology, marketing, and design have had several approaches for triggers, but they mainly focused on making a single decision with the initiators. However, to build lasting behavior, exploring the role of strengthening triggers are more crucial. Hence, besides trying to raise expectations for a new product using *Initiating Triggers*, we better design triggers that give many feedbacks placed within the users' routines, that is matching to their social norms while giving them control using *Strengthening Triggers* (table 1).

3.2 Pleasure Trigger from Game Theory

We studied game design for researches on pleasure and about its experiences. It is a framework that allows players to immerse themselves into playing games continuously.

In table 2, we have reclassified LeBlanc (8 types), Schell (11 types) and Walsh (22 types) who respectively classified the feelings of pleasure while playing the game with three categories we suggest in this article. The three categories are *internal, external* and *interaction* (fig. 4), and they are factors affecting one's emotions. With *internal*, factors of changing, emotions take places inside a self, while the *external* from outside of the self. *Interaction* is expressed emotions through relationships with others or interactions with external environments.

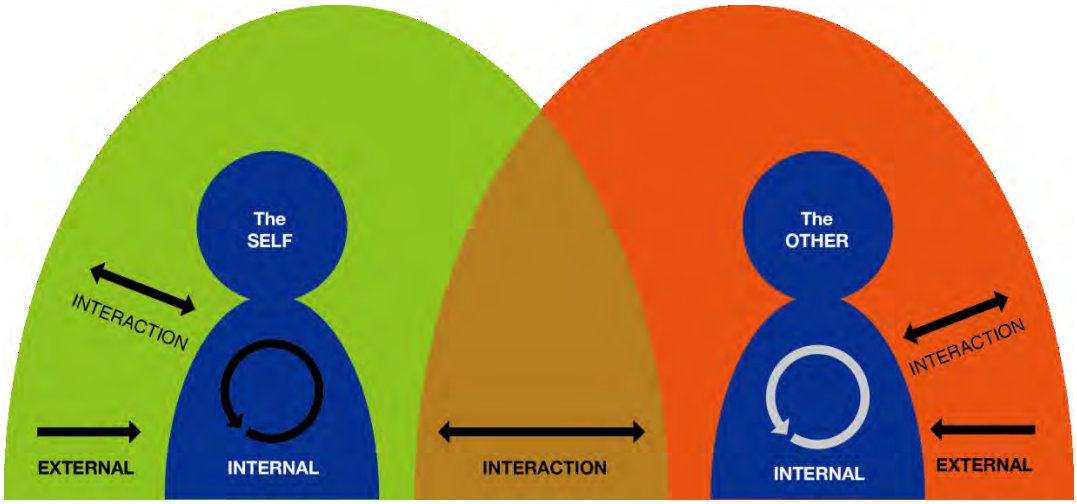

Figure 4. Internal, external, interaction Map

We drew an affinity diagram of 34 types excluding few overlaps of 41 pleasures after its reclassification in table 2. We discovered two things through this process. First, motivations for pleasure were summarized in nine keywords with three categories we suggest in fig.4. These possible types of triggers promoting pleasure are *anticipation*, *sensation, possibility, competition, self-identity, unexpected, socializing, control,* and *triumph & pride* (fig.5). Second, we discovered consequential relationship among the nine pleasure triggers that they can be placed with "before-during-after" time sequence.

Table 2 Classification of Pleasure with Three Categories(Fig.4)

CAT If a factor(s) affecting one's emotion comes from...	**LeBlanc's Taxonomy of Game Pleasures**	**Schell's Pleasures**	**Walsh's the 22 PLEX Playful Experiences**
Internal	*Submission,* the pleasure of entering the magic circle by leaving the real world behind	*Anticipation,* the pleasure of waiting for pleasure to come	*Control*, dominating, commanding or regulating
		Pride in an Accomplishment, pleased satisfaction	*Fantasy*, an imagined situation
	Fantasy, the pleasure of imagining yourself in another world	*Triumph over Adversity,* accomplished after a long shot	*Relaxation*, relief from bodily or mental work
			Captivation, forgetting one's surroundings
External	*Sensation*, the pleasure of using senses	*Possibility,* having many choices to pick one of them	*Completion*, finishing a major task or reaching closure
	Challenge, a pleasure to have problems to solve	*Wonder,* overwhelming feeling of awe and amazement	*Sensation,* excitement by stimulating senses
			Challenge, testing abilities in a demanding task
		Purification, making things clean (e.g., clear level or eat all dots)	*Cruelty*, causing mental or physical pain
	Discover, seek and find something new or exploration of a game		*Discovery*, finding something new or unknown

	world or discovery of a secret feature or strategy	*Surprise*	*Eroticism*, a sexually arousing situation
			Exploration, investigating an object or situation
		Thrill, experiencing terror but feel secure in safety (e.g., roller coaster)	*Simulation*, an imitation of everyday life
			Suffering, loss, frustration or anger
			Thrill, excitement derived from risk or danger
Interaction	*Expression,* the pleasure of expressing oneself and creating things	*Gift Giving, the* surprise of a gift	*Competition*, contest with oneself or an opponent
			Fellowship, friendship, commonality or intimacy
	Fellowship, everything enjoyable about friendship, cooperation, and community	*Humor,* two unconnected things unified by a paradigm shift	*Expression*, manifesting oneself creatively
			Nurture, taking care of oneself or others
			Submission, being part of a larger structure
			Subversion, breaking social rules and norms
	Narrative, the pleasure of telling a story of dramatic unfolding of a sequence of events	*Delight in Another's Misfortune,* unjust person's sudden comeuppance	*Sympathy*, sharing emotional feelings
			Humor, fun, joy, amusement, jokes or gags

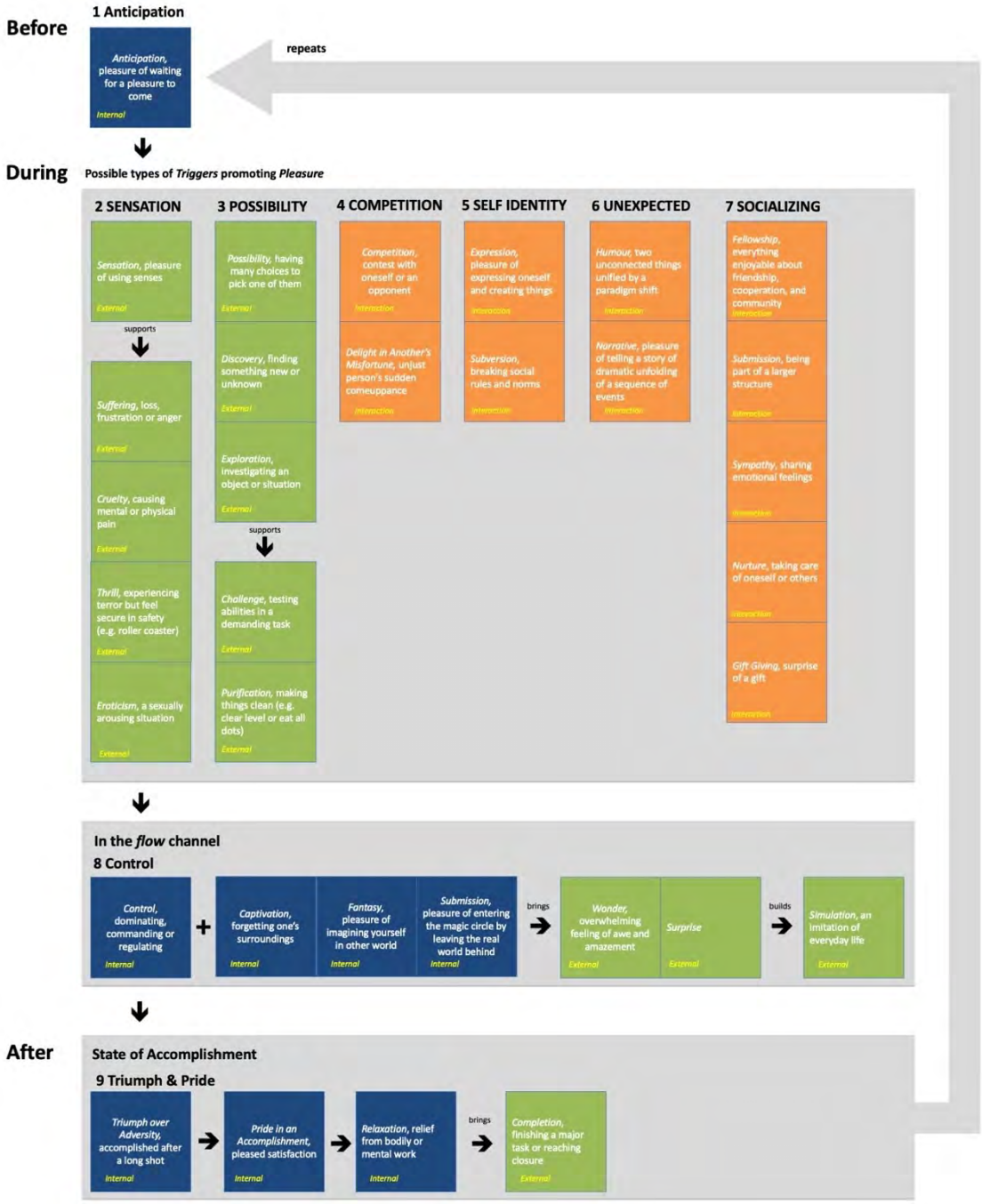

Figure 5. Relationship Map of Triggers promoting Pleasure developed from Table 2

Characters of triggers are different for action stages in time sequence. Triggers in the "during" stage help users directly to shape experiences, and those in "before" and "after" help users to be prepared for and relax after the experience. Thus, when designing a set of triggers, designers need to consider which stage the player in on for his/her action paths.

3.3 Mapping Design Triggers with Pleasure

In this section, we will explain pleasure triggers deducted from an integrative exploration of BBD toolkit and three studies on pleasure as shown in figure 5 and 6.

- *Anticipation* comes "before" the behavior happens. It is a pleasure of waiting for a pleasure to come. If a prior experience left a sense of accomplishing, the pleasure would

be optimized. Therefore, understanding the way to trigger this emotion will be a key factor for the desired behavior continuously takes place. It goes with initiating triggers of BBD toolkit, which are "positive expectations" and "pre-commitment."

- *Sensation* is a pleasure of using senses. Suffering, cruelty, thrill, and eroticism bring joy, and sensational triggers can support these kinds of experiences. Players are thrilled when they face danger but has control over the situation. It is the strengthening trigger that brings out "positive memories of similar experiences." Also, it can make someone know "consequences of their actions" intuitively.
- *The possibility* is the pleasure of having many choices to pick one of them. It is the discovery and exploration of new things. If there are a proper level of challenges and purifying actions, this will strengthen players' behaviors to play the game. As players get more options of levels or choices, they will be more "surprised," and retain "credibility" toward the action.
- *Competition* is a pleasure through contesting with others. According to the game theory, players are delighted to hear and see (unjust) character's sudden comeuppance. Through competition, users "align their identity with the desired outcome."
- *Self-identity* is a pleasure of expressing oneself creatively. It can strengthen the action of breaking social rules.
- *Unexpected* is a pleasure of talking through humor and narratives. Players enjoy the unexpected ending of a story because it is different from what they know well. By "highlighting personal stories," people will emerge themselves to the service of a new product.
- *Socializing* is a pleasure of being with others and part of a community. Fellowship, submission, sympathy, nurture, and gift giving come into this type of pleasure.
- Mihaly Csikszentmihalyi (1990) claims that as long as we receive a challenge that fits our skill level, we will be engaged to handle the challenge. Thus, *Control* triggers the player to be in the 'flow' channel because having control over one's action means challenges are good enough to handle, providing autonomy to one's action. Therefore, "associate new behavior with an existing routine" will give the player "ownership."
- The pleasure of *Triumph & Pride* comes "after" the behavior. It is a pleasure of completing what player set to accomplish. In the game, the longer the player's adversity, the stronger one's enjoyment. However, from strengthening perspective, the pain should not be too long without any gains. Thus, small gains provided to players in every step of one's action will be critical behavioral triggers.

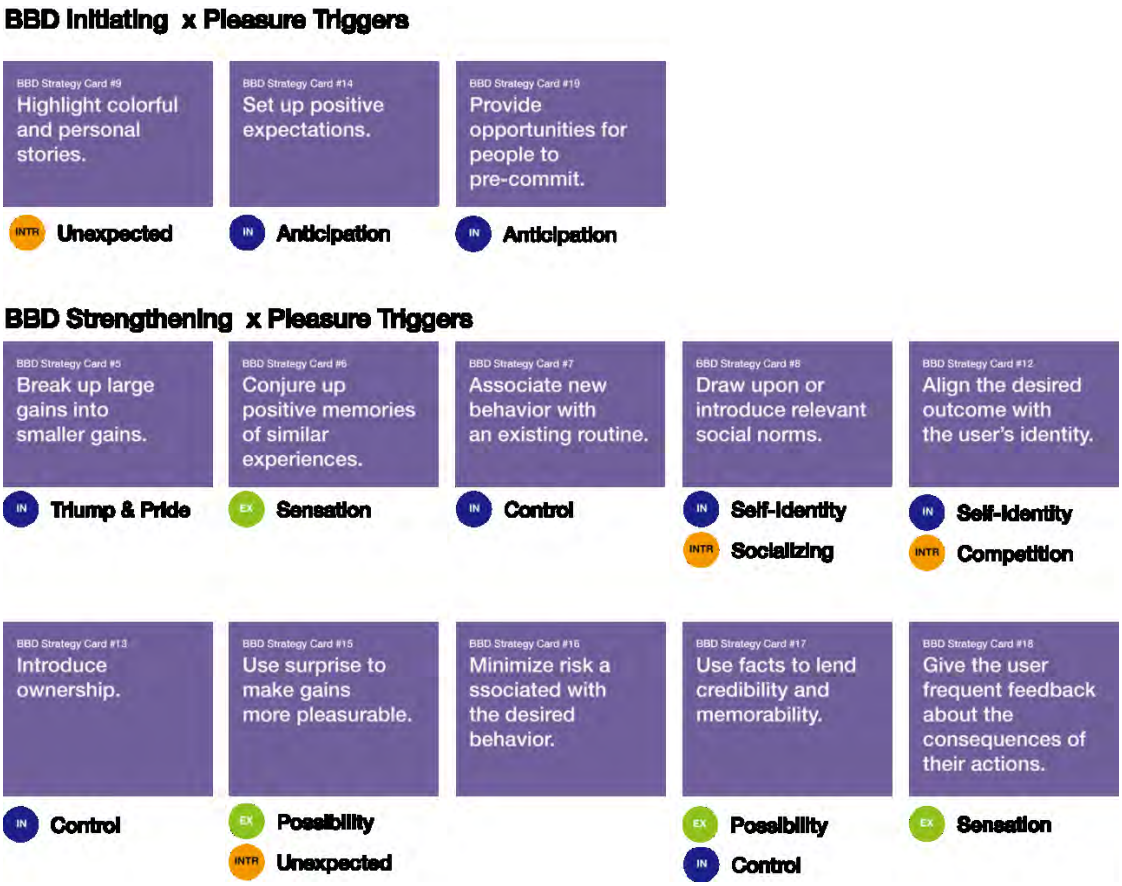

Figure 6. Relationship map of triggers from BBD toolkit and the Pleasure Triggers from fig. 5

4 Trigger Design Circles

This paper studied various theories and models on behaviors and pleasure to develop a roadmap for a lasting behaviour using pleasure triggers.

The paper proposes *Trigger Design Circles* as a design framework to analyze action paths that people repeatedly choose to do. As shown in fig.7, it has three leading circles: a striped new habit circle, a circle with a gap between the desired and actual behavior, an old habit circle. There are seven factors of behavior in the *Circles*: GL(Goal), DB (Desired Behavior), AB (Actual Behavior), TR (Trigger), OT (Obstacle), OH (Old Habit), and NH (New Habit). They are interrelated factors.

To use the *Circles* for behavioural design, it is crucial to acknowledge that there is a gap between behavior that actually takes place (AB) and behavior that user desires (DB). DB is the user's goal. The second statement is that an OH is quite powerful that TR gets interfered by OT such as "performance location, preceding actions, interacting people" of a user (Wood & Neal, 2007). However, if followed with proper types of triggers as mentioned in fig.5 and 6, it is possible to break out of the OH and build a new behavior achieving the GL. As these circulating processe repeats with proper triggers on each stage, the user will eventually break out of OH, and behave under influence of NH circle.

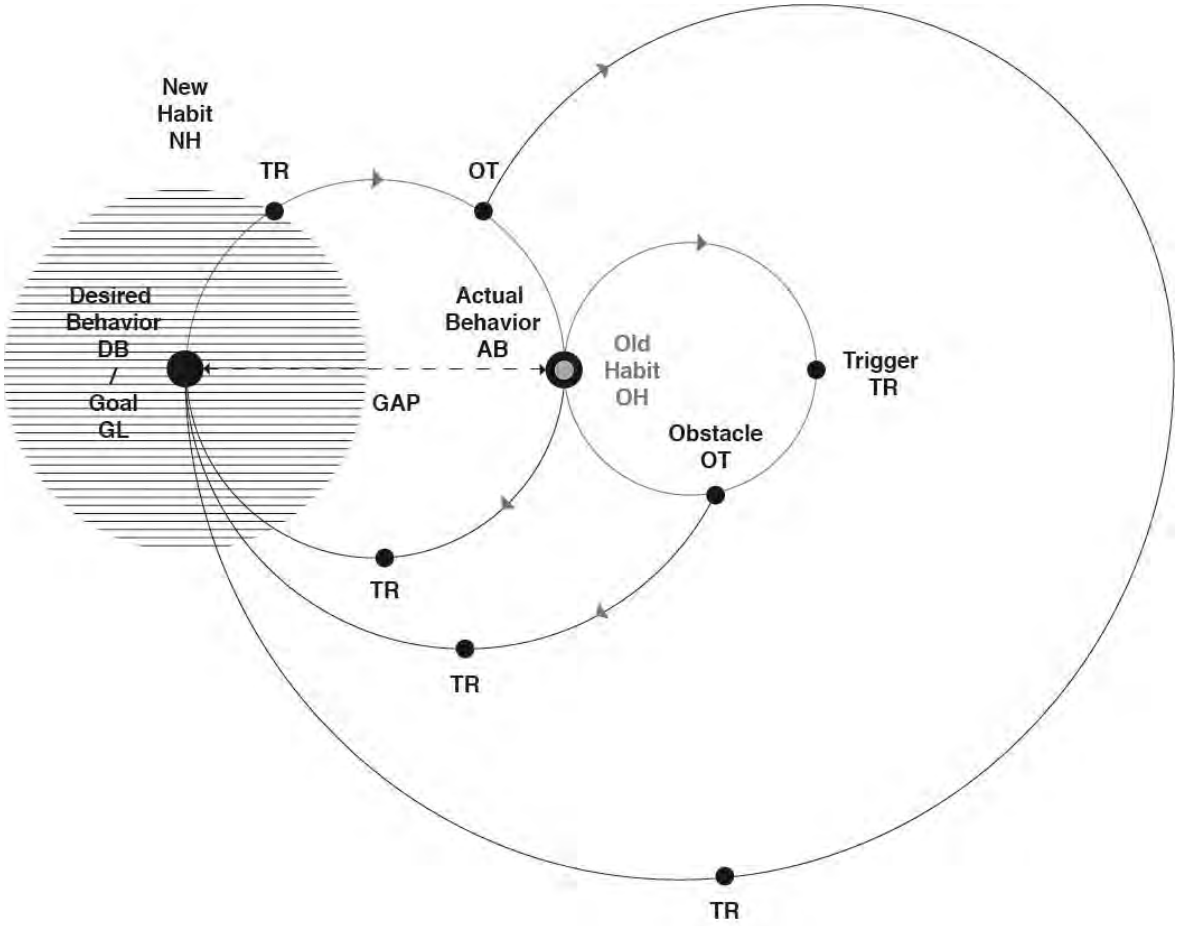

Figure 7. Trigger Design Circles

5 Discussion and Further plan

This study recognizes the need for study in pleasure triggers as a behavioural design strategy to continually practice the desired behaviors. In order to develop a strategy for lasting behaviors, the paper organized trigger design elements under ‘before-during-after' time frame of when pleasure experiences take place. Nine pleasure triggers with the *Trigger Design Circles* are the result of the study.

Currently the study is work in progress. We plan to test and modify the models through couple of workshops. These design workshops will be conducted under themes of health, pro-environmental, digital detox issues. The reason to focus on these issues are that they are hardly maintained but beneficial to our lives if practiced well. People usually do not see consequences of their habitual actions, and this tendency actually became a major threat to the survival of mankind. With pleasure, people accept changes more softly because it brings out positive feelings from them. Therefore, we will continue to develop trigger design with pleasure as the key strategy to shift our daily behaviors into better ones for our future.

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Urban regeneration of the Central District of Taichung city – A culture creative approach based on service design

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In recent years, the topic of space renovation has seen growing awareness in Taiwan. It becomes an opportunity to condense culture and creative art and build a city connection. As being the first urban planning district in Taiwan, the Central District of Taichung City has gone through prosperity and depression iteratively. This research first examines the ecosystem of cultural industries in this District where comprised a great majority of art cultural festivals; homemade craft shops, selection and coffee shops; rich historical and cultural heritage, civilian architecture, and more. To respond to this investigation, an exhibition consists of documentation and craft creation is initiated to explore the future of regeneration within this area based on service design. The research result shows that a new service system could have a significant impact on the future development and operation of the business circle in this District.

Keywords: urban regeneration; culture and creative art; service design

1 Introduction

In terms of the process of urban regeneration, the role of culture has become a major and often driving factor in recent decades. It has been significantly extended as a factor in regional transformation in response to both competition among cities and sustainability demands in cultural industries (Sepe, 2013).

Since the 1980s, the creative city (Landry, 2008) started to become a new broad strategy trend, which applies to not only developing the economy but also revitalizing city neighbourhoods and communities. Through regenerating a discarded region, culture is acting an important role to form the creative city. This process has been seen in many cities in North America, Europe, and Britain (Glasgow, Liverpool, etc.), which have turned the arts into a means of branding or re-imaging the city. That is to say, cultural facilities and activities are becoming a significant component in the formation of the creative city. In the above mentioned, cases of creative cities are more focused on how to improve the interaction regarding building regeneration, economic development, and social renewal to develop the city more comprehensively. (Carta, 2004; Florida, 2005).

Moreover, the regional cultural features of creative cities are differentiated in the design, promotion, and activation of urban areas. Some areas have become creative clusters because of the realization of economic and structural innovation projects associated with regional development strategies based on economic distinction, culture, and territorial quality. In terms of a cultural ecosystem, many international cities are going through a significant structural transformation from an emphasis on traditional industries towards cultural industries based on new service design and innovation. The cultural industries drive the transition and innovation of regional cultural features to a knowledge economy.

With attention to several well-known case studies and media coverage, we keyed in on the recently popular trend of exploiting or renovating the spaces which lead to form the phenomenon of a creative cluster. Especially for some creative cities and communities in Europe, Britain and North America, there are a majority of design cases which utilized discarded or inactive spaces and factories to shape the new image in the region. Similarly, we also found that there is a greater number of buildings and spaces with the identical method to be renovated in the Central District of Taichung City.

Exploring the interactions of the cultural ecosystem in Central District of Taichung City, there are great quantities of historic buildings under renovation and re-imagining. One of the most famous cases is Miyahara, which was an ophthalmology clinic in the 1970s, but now become a gift shop that selling an assortment of tea, desserts and ice cream. The Miyahara building functions as important role in assisting this area to form a unique and attractive urban core. Secondly, a dense cluster of social networks and interactions exist in the area, showing that these industries may become creative clusters that make positive impact on enhancing regional economic development.

This paper examines the ecosystem of cultural industries in the Central District of Taichung City. The aim is to deeply understand the structure of cultural industries' ecosystem, development trend, problems and potentials in this District. However, we found that the present situation of the interactions and regional connections involving shops, industries and buildings in this area are developed in a scattered manner, lack comprehensive integration and systematic planning required to construct a well-managed cultural ecosystem.

As a result, this paper mainly uses Service Design as a methodology to comprehensively and systematically discuss the interaction of the current ecosystem which can be turned into a useful, usable, effective service system in this region. A curation team is formed to plan an exhibition containing local industry documentary collections and art and craft creations. Through the user-oriented, inter-disciplinary and systematic approach for service design, this paper focuses on examining how service design will affect the urban regeneration of this region.

2 Literature Review

The idea of creative and cultural industries has drawn the public's attention in various domains. The first concept of 'creative industries' was coined in the UK in 1997. The term "creative industries" has various representation in different countries. The cultural heritage and components of its creative activities based on local traditions and arts are usually emphasized in most European countries (Skavronska, 2017). At a basic level, cultural industries require creative ability and skill since it includes the production of traditional cultural products in the visual and performing arts, music, and literature, as well as

contemporary production of ‘content’ in multimedia, software packages, computer games, design (graphic, web, furniture, fashion, etc.) and architecture (Enlil, et.al, 2011).

Arts, Cultural and media sectors in the Cultural industries have been converted into creative industries and the consumption of these creative outputs lay the foundation of the capitalist economy in the post-industrial paradigm (Slottje, 2015). Creative City theory addresses the probably notable effect on city dynamism, growth and creative development due to its ability to renew and reinforce the regional culture specification and quality of life. A desirable and better living creative city gathers active, experienced and creative citizens and integrates their ideas. The intention is to reinforce and grow participation in all life aspects that trigger targeted development in every city. Since the concept of “Creative” is related to “artistic” and “culture” in some situations, the creative economy has been commonly discussed along with culture and cultural policy (Gwee, 2009).

Moreover, service design was originally considered in the discipline of marketing and management that uses “service blueprint” to map the process of a service event and service’s essential functions in an objective and explicit pattern for documenting and arranging service activity into a systematic code. Documenting the interaction throughout the customer lifecycle between customers and organizations is represented in the service blueprint. It had been developed as a methodology for emphasizing the influences of the service process that occurred in the physical environment and explaining the behaviour of people in this service environment. Service design was later applied in design field in which more and more creators and companies use it as a methodological approach not only for understanding people’s activities, communication, infrastructure involved in service contexts but also as a way to enhance the interactions between service providers and their service recipients (Mager, 2009). In short, service design is a user-oriented, inter-disciplinary and systematic approach for investigating customer experience and the quality of service implementation to create better and closer relationships between customers and service offers.

In this research, several service design activities and tools, such as empathy map, persona, customer journey and service blueprint are applied to systematically investigate the customer's experience, the current cultural ecosystem in the Central District of Taichung City, and potential service system that would provide encouraging urban regeneration. The result of implementing service design in our case is to reach the design concept of craft creation and the planning of exhibition for exploring the future possibility of cultural creative industry in the Central District of Taichung City.

3 A culture creative exhibition planning based on service design

In early Taichung, under Japanese colonial rule, the control of commercial activities led to the cluster and development of particular industries. The local economic structure was scattered and distributed in rural areas, gradually forming an aggregated economy of urban settlements, and a city with the core economic development of the central metropolis of Taichung. For example, there are many jewellery stores on Zhongshan Road and many fabric stores can be seen on the Chengkung Road in Central District of Taichung City. Lots of cultural creative activities and exhibitions have been curated in this area and used to trigger a rebirth of the local industry. To initiate the planned exhibition and craft creation activity in this research, a survey of recently held exhibitions and interview with some

subjects were first carried out and followed by several service design implementation approaches. The opportunity to curate a cultural creative exhibition and craft creation in response to urban regeneration is then identified.

3.1 The scenario and persona based on an interview

The service scenario and persona are set up based on the empathy map method along with face-to-face interview. Some quotes retrieved form interviewee are listed as follows:

“I was stopped by a stylish poster.”

“I totally had no idea what was going on before walking in the exhibition. But I found that it’s so lively and interesting after I walked in.”

“The most impressive demonstration was that the performing artist would assign some tasks to participants and lead an unpredictable consequence.”

“It would be better if I can get a poster from the exhibition because I would hang it on my wall.”

A virtual character represents the targeted participant of cultural creative activity is created as shown in figure 1.

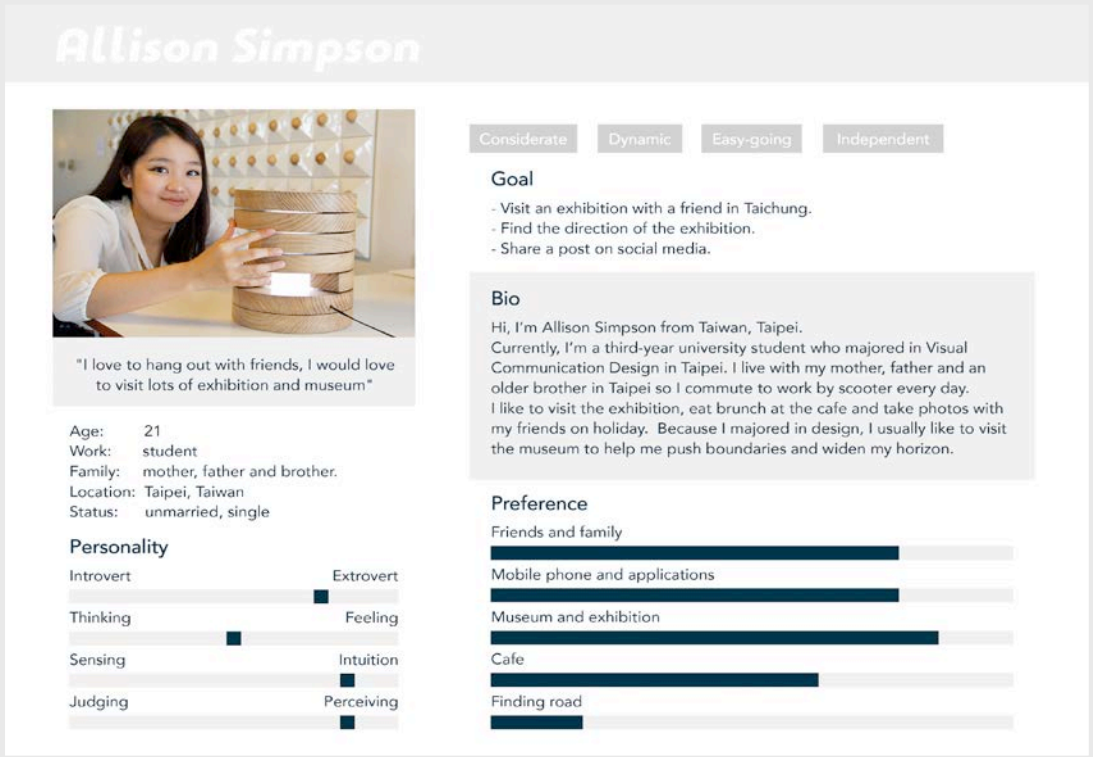


Figure 1. Designated persona.

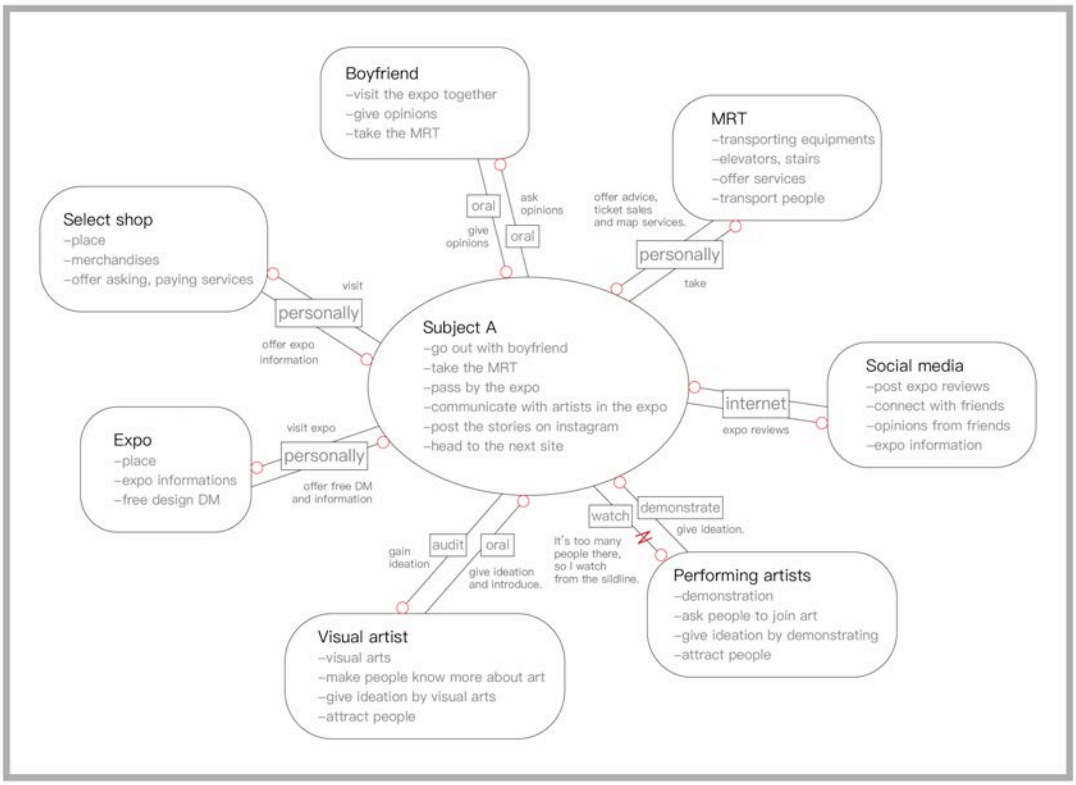


Figure 2. Interactive behaviour.

The diagram (Figure 2) shows the information about the interaction during the period of visiting an exhibition which mentioned in the above interview. Three design point of view are listed in “how might we” format: How might we create an interactive approach to offer the five senses experience to visitors? How might we provide a “wow” guidance to reach the venue during visitors’ exploratory finding journey for visitors? How might we create a specific atmosphere where the volunteers can merge well into the site in order to do performing with exhibits for visitors? This paper will focus on the topic of “How might we create an interactive visiting approach to offer the five senses experience to visitors?” as the main design viewpoint.

3.2 Customer Journey

A customer journey is analyzed to figure out possible touch points provided by the service system from the user’s perspective (Figure 3).

3.3 Service process

The Service Process Matrix is a QFD-like table which is deployed from the demands to functions, and from the functions to the processes in order to identify and confirm the must-needed service functions and the required service processes. Service Resource Matrix then identifies the service resources which can help us to seek and confirm the items that are indispensable for the exhibition based on the service functions and corresponding processes. Using the demand of “Get the exhibition information” as an example. In order to achieve this demand, we need to perform a variety of functions, ranging from: scan QR codes, view the information posted on the official website, search direction on Google map, search transportation, see 3D posters which designed to attract visitors on road, and understand the background stories from cooperated local stores.

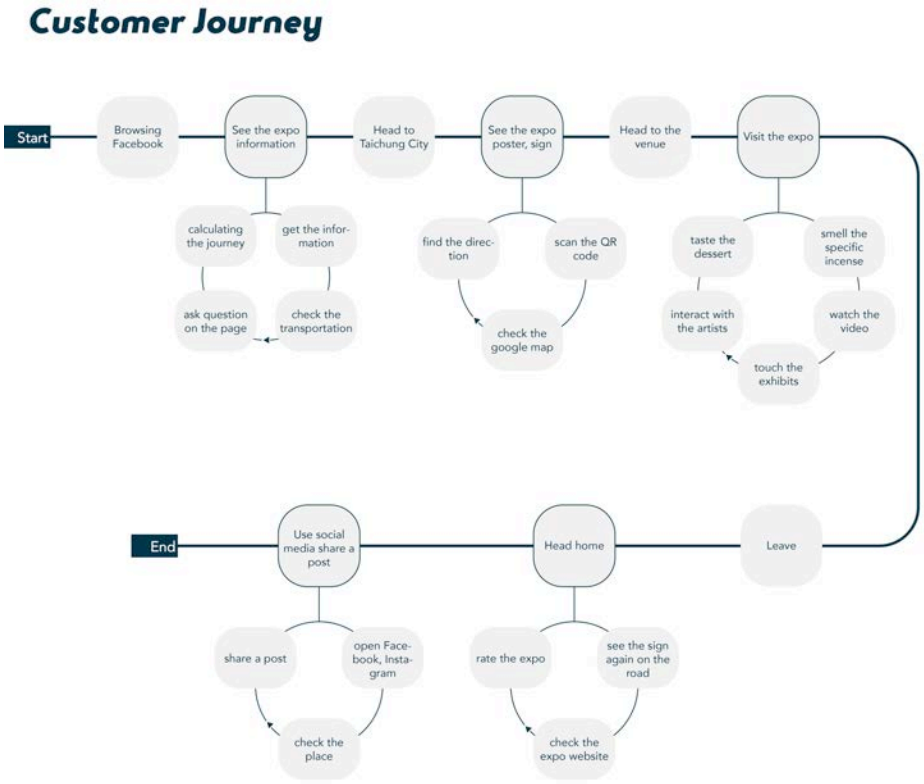


Figure 3. The customer journey.

4 Exhibition Design

4.1 Introduction

The urban old town is like a city's precious treasure, with a huge number of stories that haven't been explored yet. The old shops that have been passed down through generations in the Central District of Taichung City carry a long-lasting culture. There are many famous old shops and industries in this area during previous decades, or even over a hundred years. These industries are still extending the preferences of our generations as well as represent the true city life culture.

Although the urban area has fallen gradually, these stores remained. They are continuing their credit and commitment to customers and show their meticulous care and service belief as well. With attention to this exhibition theme of local economic structure in the Central District, our aim is to implement the concept of "human-centered design and social connection" as well as represent specific cases of "visible local industries, community, and urban landscape". Through the process of service design for more deeply understanding about visitors and the local industry, the consensus of the curating exhibition context and the information transmission regarding industries can be reached. Additionally, we explore issues such as "the imagination of flipping over these dimmed industries", "revitalizing the image and value of faded houses", "the possibility of residents' participatory design to change the community" and "discussion on the residents who live in the depressed areas". The most important thing is to promote the spirit of perseverance as the way to revitalize the core values of community power.

During May 22 to May 31, 2019, the venue of this exhibition in our study was chosen in the renovation of the old house – Liu Art Museum. In addition to the creations from two artists, the story of the industrial development, culture, and history of the Central District since the Japanese occupation era was shared in the form of a documentary exhibition that enticed all five senses. Therefore, this exhibition not only presents the Human-centered design concept but also highlights the core value of social connections between the people and the Central District of Taichung City. It represents the precious values driving the core of Taichung City prosperity during the historical period. These specific features clustered densely in this under 1 km² district (Figure 4).

4.2 Exhibition planning (predefined exhibition site – Liu Art Museum)

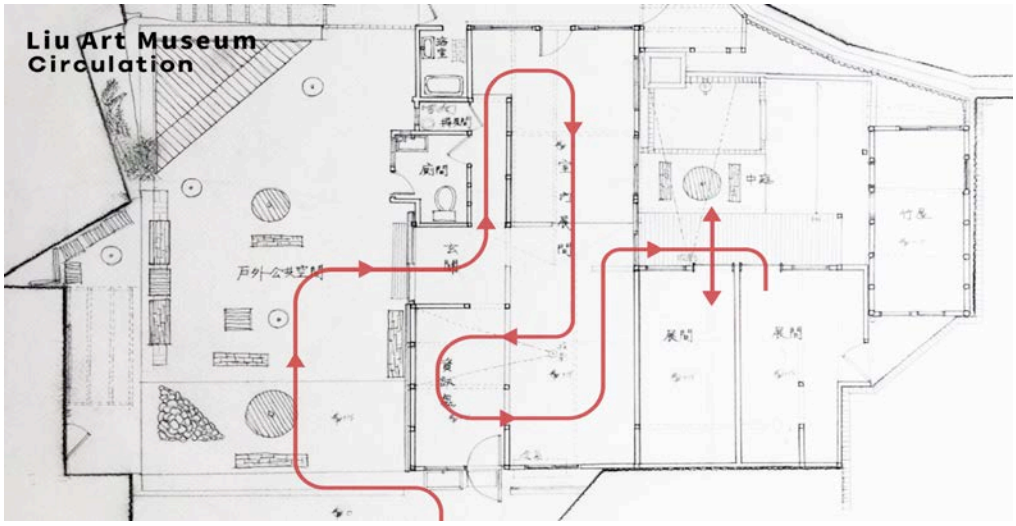


Figure 4. Site circulation of Liu Art Museum

4.3 Sketch

The design process involved lots of sketch drawings (Figure5) to express the imagination of particular industries in the Central District of Taichung City. Their connection and implication of respective industry with sketches based on interviews are listed in Table 1.

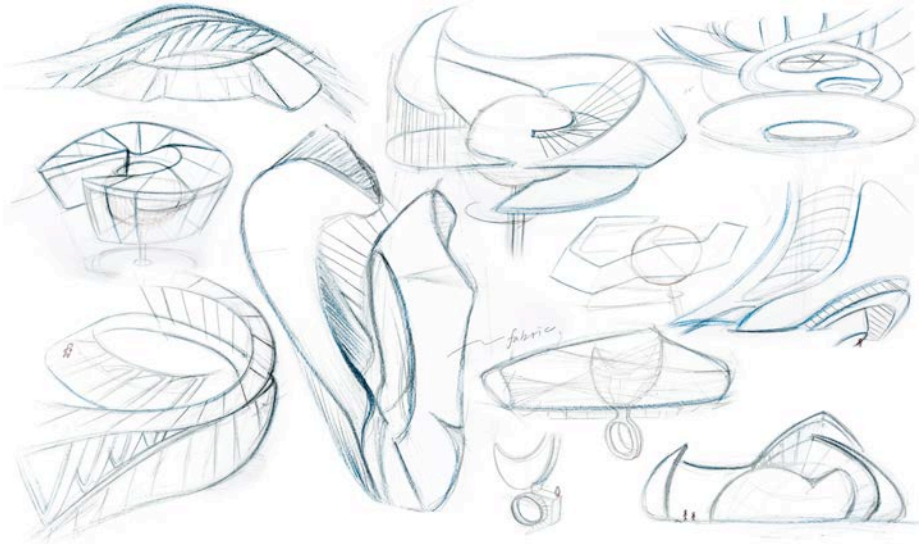
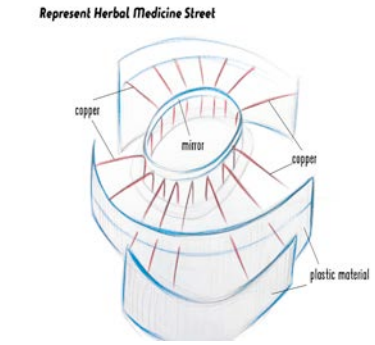
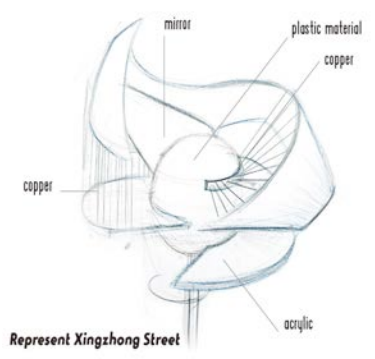
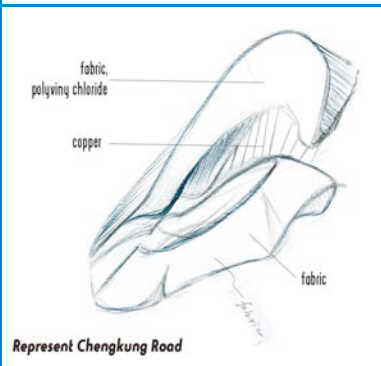


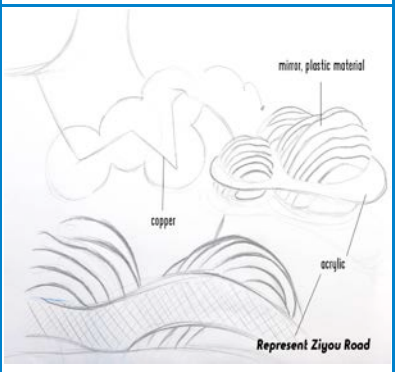
Figure 5. Part of sketches

Table 1. Connection and implication of particular industries with sketches based on interviews







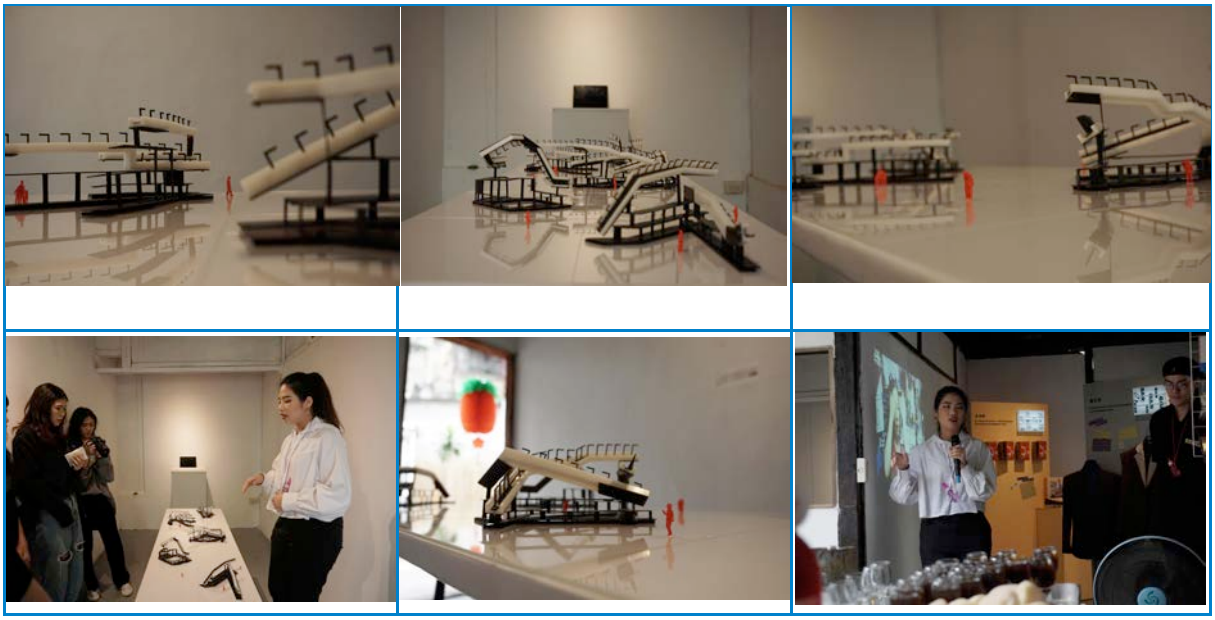


4.4 The exhibition – Middle Man

Taichung City is located in the centre of Taiwan, while the Central District is the original centre of Taichung. The people who live here are then the "middlemen". If there is no "middleman", where does the Central District come from? If there is no Central District, how come these "middlemen"? People and the city have always been inseparable, whether you

are passing through or walking in the Central District, or living in this area, you have quietly become a "middleman." As a "middleman", we have a series of stories between the citizens, districts, cities and exhibitions in the Central District. In the exhibition, five neighbourhoods are selected to represent an industry respectively. in addition to craft creation, text and video materials, we also display representative items of the particular store (Table 2).

Table 2. Exhibition at Liu Art Museum



5 Conclusion

This paper has proposed a service design approach that plays a significant role of branding and re-imaging a territorial region to drive the Central District of Taichung City. We have mainly established a culture creative exhibition to widely connect these independent traditional industries which have clustered for decades as a specific economic system. The exhibition connected local industry with cultural creative events which attract more attention regarding urban regeneration. Collecting data (questionnaires, surveys, interviews), choosing exhibition venue, and finalizing the context of this exhibition were executed during exhibition planning. From the curators' viewpoint, there are inevitably some shortcomings in the project planning due to inexperience and financial limitation.

In summary, the team was gratified by the exhibition result and received positive feedback from curators, visitors and the selected local industry. Some reviews are appreciated and listed below as the justification of the performance of curating exhibition.

"I've understand the stories of the local industry located in the Central District more."

"I really agree that the crafting objects were corresponding to the core value of the exhibition."

"The main elements can be seen on the exhibition planning."

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MAKING

DESIGN AND MAKING ARE INTRINSICALLY LINKED, BE IT THROUGH THE USE OF THE HAND OR THE MACHINE. THE CREATIVE POSSIBILITIES OF MATERIALS AND PROCESSES HAVE LONG BEEN HARNESSED BY DESIGNERS TO INNOVATE. WHAT MODELS OF PRODUCTION, FABRICATION AND MODIFICATION ARE GOING TO SHAPE THE FUTURE? HOW ARE MATERIALS SHAPING DESIGN AND HOW ARE DESIGNERS SHAPING MATERIALS? IS THE DEMOCRATISATION OF MAKING A POSITIVE OF NEGATIVE ISSUE FOR DESIGN?

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International Association of Societies of Design Research Conference 2019
DESIGN REVOLUTIONS
Manchester School of Art
Manchester Metropolitan University
02-05 September 2019

Craft and Sustainability: Reflections on Design Interventions in Craft Sector in China

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Current studies show that sustainability has evolved from a static goal to a more comprehensive and systematic understanding. Notably, in the implementation of sustainability, there is a need to shift focus onto locality, using local knowledge to solve local problems. Due to a focus on small scale hand-making and a common emphasis on local knowledge, making practices are essentially consistent with sustainability. In addition, self-transcendence values and conservation values are also embedded in these crafts, which reflects in their ecological wisdom, responsible making philosophy and their contributions to personal wellbeing and social stability. Therefore, strong connections between craft and sustainability, emerging from theoretical research, indicates that crafts can be as a modern way of thinking. However, nowadays, in China, due to the influence of globalization and modernization, some traditional heritage crafts have been marginalized. Facing this problem, a preliminary research has been conducted based on secondary data and research, in order to make sense of the current craft sector and related design practices in modern China. The contribution of this paper is to 1) reveal strong connections between craft and sustainability, 2) categorize craft revitalization practices happening in China, 3) identify design's contributions in crafts revival in China and 4) point out problems related to sustainability in design interventions in the Chinese craft sector.

Keywords: craft; sustainability; design interventions; crafts revival in China

1 Introduction

In China, crafts are positioned within cultural fields, primarily in the field of Intangible Cultural Heritage (ICH) (see ICH China http://www.ihchina.cn/). By December 2018, 40 Chinese folk arts and crafts had been included in the UNESCO Lists of Intangible Cultural Heritage, and 3152 examples with 10 categories are inscribed at the national level (UNESCO; ICH China). Although many traditional crafts have been listed into ICH, this does not necessarily mean that they are well-protected. In contrast, some of them, today, often seen as being out of step with modern society and disconnected from people's daily life (Jung et al, 2015). Consequently, many local craft makers cannot make a decent living, and thus there is a break with traditions in the community as fewer young people are willing to devote themselves to local craft production (Zhang, 2011).

As the Plan on Revitalizing Traditional Crafts was released by the Chinese State Council in 2017, there has been a wave of crafts revitalization practices in recent years. Notably, these craft practices are being influenced by modern market and being re-reshaped by technology (Chinese State Council, 2017). However, led by such directions, some problems come out, such as: waste of nonrenewable materials (e.g. rare metals and jades) during the making processes; craft educational system with a strong emphasis on digital technology but less focus on traditional skills; and limited quality management, which leads to many craft products of poor quality (Zhang, 2011). Facing these problems, this current research of which this paper aims to understand the relationship between craft and sustainability and make sense of crafts revitalization practices happening in modern China. Analyses of the literature and related secondary data discuss here is the first part of a longer study that with exploring design's potential role in line with sustainability, in order to reviving traditional heritage crafts in China.

2 Understanding pathways to sustainability

In 1987, Our Common Future was published by the World Commission on Environment and Development, and sustainable development was introduced as a 'global objective', advocating the re-examination of development issues and seeking for international cooperation (WCED, 1987, p12). Since then, the notion of sustainability has been welcome for showing a way out of impending doom (Kuhlman & Farrington, 2010; Walker, 2006, p17), and it was widely seen as an appropriate model which would not sacrifice the possibility of future generations to meet their needs (WCED, 1987, p43; Ceschin & Gaziulusoy, 2016). Its popularity can be reflected in the United Nations Conference on Environment and Development (UNCED), which took place in Rio de Janeiro in 1992; political leaders from all around the world promised to support this goal (Dresner, 2008, p2).

In general terms, sustainability addresses three interrelated areas, including "environmental stewardship, social equity and justice, and economic issues" (Walker, 2006, p16). However, as a continuously growing concept, the idea of sustainability is still ideological, immature, and complex (Reubens, 2010; Faber, Jorna & Van Engelen, 2009). This means huge difficulties emerge in its operationalization. To narrow this gap between the theory and practice, many scholars have discussed different pathways to sustainability in the literature. According to different perspectives, the authors categorize them as four main pathways as bellow:

- **The pillar-based pathway** is an attempt to understand sustainability on a number of modern disciplinary categories, with an emphasis on their interconnected and interdependent relationships.
- **The technology-dependent pathway** focuses on eco-modernism, and it relays on technological and innovative approaches to improve eco-effectiveness/eco-efficiency.
- **The goals-based pathway** addresses global challenges in a more specific way, with an emphasis on transforming general sustainable goals into a local context.
- **The systematic pathway** considers unsustainability as a systematic problem, and it suggests a process seeking balances.

2.1 The pillar-based pathway

The WCED sustainable goal and the Triple Bottom Line (TBL) (Elkington, 1999, p70) respectively reflect the two pillars version (ecological and socio-economic) and three pillars version (environmental, economic and social). And after this, there have been attempts to add more components which are more strongly related to the field of sustainability. For example, culture has been considered as the fourth pillar by the committee on culture of the world organization of United Cities and Local Government (UCLG) (2010). And a quintuple framework with the complement of cultural and political considerations was proposed by the Canadian International Development Agency in 1997 (cited in Gibson, 2006, p17). It is noticeable that, in the literature, these pillars sometimes are replaced by intersecting circles. Similar to pillars, the role of these circles is to identify areas in which damage must always be avoided and improvements always be sought, but in contrast to the pillars approach, the understanding of contributions to sustainability is asserted in the intersected area (Gibson, 2001, p11).

However, in the real world practicing this pathway, one pillar often needs to make compromises, and thus this approach raises competition between different components. one typical example is a common deeply entrenched debate between the economic pillar and the ecological pillar, which is re-presented as the fierce debate between “strong” and “weak” sustainability in academia (Nugraha, 2012, p48; Gibson, 2001, p11; Kuhlman & Farrington, 2010; Dresner, 2008, p81).

2.2 The technology-dependent pathway

Ecology-based Modernism continues the most influential parts of the so-called Outlaw Designers - Jay Baldwin, Buckminster Fuller and Stewart Brand - from the 1960s to 1970s (Benson & Fine, 2010). Instead of a linear design process, modernism embraces nature’s model of “waste equals food”, and regenerative technologies are used to “close the loop” (Braungart, McDonough, & Bollinger, 2007; R. Stahel, cited in Benson & Fine, 2010). Based on this, many concepts and visions have been developed, such as green design which follows the principles of reduce-reuse-recycle (Burall, 1991; Mackenzie, 1997), eco-design which focuses on the less use of energy and materials in the whole life-cycle of production (Ceschin & Gaziulusoy, 2016), Biomimicry which argues mimicking nature’s forms, processes and ecosystems (Benyus, 1997).

However, although research on eco-efficiency has showed positive changes in far less use of energy and materials than those of them decades ago, the fact is that there is still an increase in overall consumption of environmental resources because aggregate consumption continues to grow (Manzini, 2010). Reflection on this, this direction chasing for “better, preferred, improvement and optimization” based on innovation and technology is not enough, because “doing so perpetuates the fallacious idea that ever more products, services and choices will automatically improve our lives and make us happier” is problematic (Walker, 2018, p272). Hence, a more comprehensive and systematic understanding is needed.

2.3 The goals-based pathway

The most typical example of this pathway is the Sustainable Development Goals (SDGs) proposed by United Nations. Compared with previous understanding in three main dimensions (environmental, social and economic), SDGs address the global challenges in a

more specific way, including those related to “poverty, inequality, climate, environmental degradation, prosperity, peace and justice” (United Nations, 2015). However, in terms of implementation, achieving this blueprint requires an “effective translation between global and national aspirations” (Biermann, Leemans & Solecki, 2017). This requirement highlights, in the process of contextualizing SDGs into place-based settings, it is necessary to be selective according to local conditions, constraints and opportunities (Rootes, 2007). As “the experience of a particular location with some measure of groundedness…, sense of boundaries, and connection to everyday life”, place-based knowledge about “culture and environmental conditions” should be taken into account in the application of any potential development paradigm (Escobar, 2001; Walker, 2018, p270). Therefore, under the guideline of sustainability, like SDGs, there is a need of a place-based transformation in line with the contextual changes, otherwise, it can be “counter-productive” due to the lack of local knowledge and thus with the end of failure, such as “ill-conceived eco-city projects Masdar, Dongtan and Huangbaiyu” (Walker, 2018, p271).

2.4 The systematic pathway

The current understanding suggests that sustainability requires a process seeking balances. This imbalance now reflects in the contradiction between opposite components, such as needs versus wants (Henry, 1996; cited in Nugraha, 2012), localism versus globalism (Dresner, 2008, p170-172), the short versus the long term (Kuhlman & Farrington, 2010), and tradition versus modernity (Nugraha, 2012, p46-47). In the comparison between primitive and modern worlds, there was a balance between “what is produced and what is desired” in the past, which results in a remarkable stability (Henry, 1996; cited in Nugraha, 2012). But unlike a fixed bundle of wants in the primitive society, our contemporary dynamics is the lack of property ceiling, as a consequence, there is an increasing growth of consumerism accompanying with excessive energy use, resource use and waste (Walker, 2018, 270-271).

In this ongoing debate, often from opposite viewpoints, people keep questioning whether the end of sustainability is localism or globalism? if we should go back to traditional ways or keep embracing modernity? In this background, a more neutral voice with the emphasis of balances achieving sustainability appears. An example is the argument of community-based distributed systems in the globalized context; this concept emphasizes the power of the local and small communities as resilient social structures, and productive systems that rely on technology and global network (Manzini, 2014; Zhan & Walker, 2019). A similar approach seeking balance between traditionalism and modernism can be found in Walker’s argument, who suggests to re-discover the value of traditions, because these “traditional ways of thinking and behaving differ markedly from the modern sensibility”, since they tend to “embody a sense of duty and responsibility not just to others in their community but also to the teachings, knowledge, wisdom and practices of their cultural predecessors” (Walker, 2018, p273-274). Learning from these positive values embedded in enduring traditional practices can help us develop a “different, hopefully more balanced outlook”, and thus help us solve sustainable problems in modern society (Ibid).

In summary, current studies show that our theoretical understanding of sustainability has evolved from a view that perceived sustainability as a static goal to a more comprehensive and systematic view (Ceshin and Gaziulusoy, 2016). This evolution shows that there cannot be an “overarching all-encompassing specific sustainability target to strive for” (Hjorth & Bagheri, cited in Ceshin and Gaziulusoy, 2016). This means, at the practical level, there is a

need to shift the focus onto “locality” (Manzini, 2010), using local knowledge to solve local problems (Van der Rym & Cowan, 2007, p83-85).

3 The value of craft and its relationship with sustainability

Craft, as an integration of theoretical knowledge, practice skills, tacit knowledge and experience (McCullough, 2010, p311; Metcalf, 1997, p69-75; Shiner, 2012, p236; Sennett, 2008, p95; Dormer, 1997). It requires a long-term cycle of accumulation with systematic learning and repeated practices. Meanwhile, belief, behavior and customs are handed down from generations to generations by traditional making practices, which ensures the continuity of symbolic cultural meaning or special significance with origins in the past. As discussed before, due to a focus on small scale hand-making and a common emphasis on local knowledge, crafts are essentially in line with principles of sustainability; and therefore, craft objects are valued due to their “longevity, timelessness and high quality” (Woolley, 2010).

In addition, in the literature on crafts, the term “value” is frequently mentioned by researchers. Therefore, a literature review on value and craft was also conducted, in order to better understand the nature of craft.

Rokeach’s book The Nature of Human Values was published in 1973 and showed that the value systems are large and dynamic. According to Schwartz’s work (1992), values work together in a circular form, or “circumplex”. And these values can be divided as four categories, namely, openness to change, self-enhancement, conservation and self-transcendence. The cluster of openness to change values and self-enhancement values are related to external approval and rewards, like “financial success (money), social recognition (fame) and financial success (money)” (Kasser & Ryan; 1996). In contrast, the cluster of self-transcendence values and conservation values are associated with intrinsic character, like community, family, religiosity, self-regard, religiosity, caring for others and affiliation (Kasser & Ryan, 1996; Kasser, 2016). In general, intrinsic values and extrinsic values are correlated, but to some extent, they are also conflict with each other. Substantial evidence has shown that extrinsic values are negatively associated with ecological attitudes and behaviors (Brown & Kasser, 2005; Richins & Dawson, 1992; Sheldon & McGregor, 2000; Hurst et al., 2013), personal well-being (Richins & Dawson, 1992; Kasser, 2002; Dittmar et al., 2014) and socially responsible behaviors (such as helping others and volunteering, Briggs et al. 2007, Sheldon & Kasser, 1995).

To explore the value of craft, we can place craft into this value context. The following analysis shows that craft falls mainly within the cluster of self-transcendence values and conservation values:

- **Universalism:** ecological wisdom is inherent in craft practices, reflecting in craft’s low impact on environment. As “the application of skills and material-based knowledge to relatively small-scale production” (Adamson, 2010, p3), locally natural materials are selected, and obviously, most of these materials, like bamboo, wood, cotton or glass, are renewable. On the other hand, a handmade process and a locally appropriate small scale of production also contribute to its less energy consumption.
- **Benevolence:** different from mass-produced products, good quality and long lifespan can be seen in craft objects. Making good is much important than making quick. This making philosophy convey makers’ belief and virtue, such as responsibility, persistence and love. And because of positive feeling aroused after making a craft

artefact, such as “self-actualization, fulfillment and happiness”, craft practices are regarded as an important way contributing to spiritual wellbeing (Ferraro, et al., 2011).

- **Tradition and conformity:** craft knowledge is accumulated through “a steady process of cultural accretion”, and such traditional designs and craftsmanship have achieved longevity by honing over generations (Van der Ryn & Cowan, 2007, p83). For craft products, they are “timeless, unique and original” with “historical significance” (Woolley, 2010, p141).
- **Security:** as local-based practices, crafts are made for a relatively firm local demand. Thus, there is a “congruence or complementarity between what is produced and what is desired” (Henry, 1996; cited in Nugraha, 2012). Such a traditional and relatively stable relationship between production and material needs can help local communities establish “remarkable stability” (Ibid). At a personal level, this stability is reflected in crafts people’s psychological satisfaction. Figure 1 shows the values of crafts in line with sustainability.

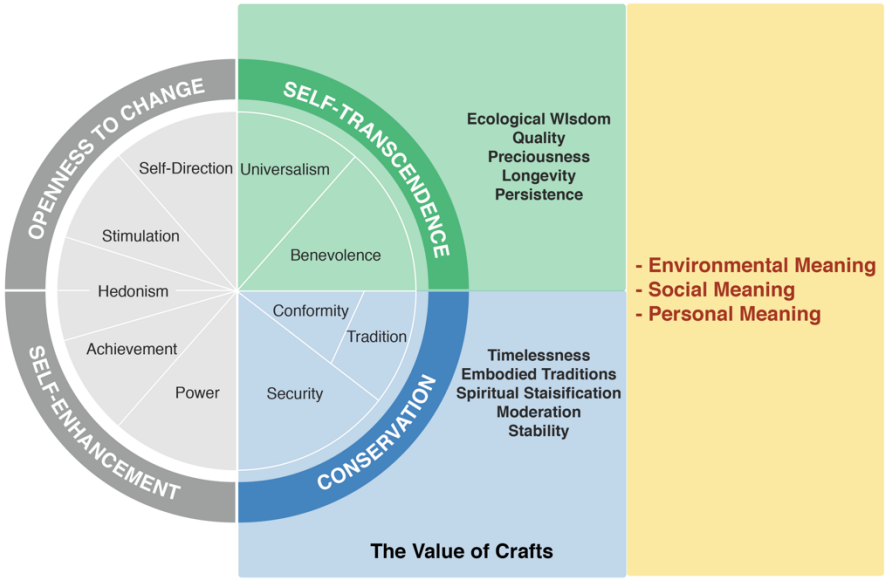

Figure 1. Values of Craft in Relationship with Sustainability. Source: developed by the authors from Schwartz’s theory (1992) and Hormes, et al. (2011)

As local-based practices, craft objects are made by local materials for local needs. Environmental integration is rooted in craft making. Meanwhile, flexible craft practices and small-scale craft production, to some extent, can contribute local communities to become more “interdependent, self-organized, nested, participatory and diversified” (Kossoff, 2015). With these distributed communities interconnected (Ibid), an “authentic holism”, opposite to “a globalized but fragmented homogeneity” world today, (Bortoft, 1996; Kossoff, 2015) can be realized. As a “catalyst”, craft practices provide us opportunities to reassess the relationship with “natural environment and with each other” (Ferraro, et al., 2011). Therefore, it is meaningful to consider craft as “a modern way of thinking”, re-learning its ecological wisdom, its responsible making philosophy and its contributions to personal welling and social stability.

4 Crafts Revival and Current Design Interventions in Crafts in China

The craft resurgence is supported by Chinese governments today, and this leads to an increasing interest in craft revitalization at a practical level. In order to have an overall understanding of current craft practices happening in China, a preliminary investigation has been conducted. Due to limited academic resources, this investigation is mainly based on online secondary materials. A keyword, i.e. “crafts revival”, were used on Chinese largest search engine Baidu. According to search results, except for government documents, related crafts revival information was normally shown on the website of big companies, in reports by academic intuitions or universities, in news about historic old brand craft enterprises, and documentary films about design-makers. For each category, 1-4 typical examples were further analyzed, and their characteristics can be identified as bellow:

- **Projects supported by big companies:** some influential crafts revival projects are launched in big companies, which aims to achieve the corporate social responsibility (CSR) and maximize their “positive impacts on society” (Jamali & Mirshak, 2007). For example, in BMW’s CSR project called Journey of Chinese Culture (http://www.bmw-brilliance.cn/cn/zh/csr/cultural.html), since 2017, its project team has conducted field research in 22 provinces with visits to 337 intangible cultural heritage in 6 national-recognized Eco-Cultural Preservation Areas. To date, more than 16,000,000 yuan (about £1,799,775) has been paid to support academic research and projects on 90 endangered crafts.
- **Research projects oriented by academic intuitions or universities:** these projects emphasis on how to solve problems and challenges in specific contexts, such as the Shouyi Nongcun project in Shandong University of Art and Design (Pan, 2011), how to attract more people to be involved in the craft sector, e.g. by in-depth craft experience activities in Hexu training programme (Kunming Government, 2011), and how to facilitate innovative collaborations in different fields, e.g. in Yicun Yipin project (Zhang, 2015).
- **Design projects led by historic old brand enterprises or design-makers:** for some historic old brand enterprises and products, like Yue ware and Celadon potteries in Cixi City, Zhejiang Province (Zhang, 2015), they integrate contemporary design elements into traditional crafts, in order to expand market. In addition, there are many modern designs based on traditional/heritage crafts, and most of them are popular in the market, like Rong project (http://www.handmadeinhangzhou.com/) and brand Wuyong (http://www.wuyonguseless.com/Default.aspx). For these designers, they get inspirations from traditional crafts, like ethnic patterns and unique place-based materials. And a collaborative model is normally adopted by them to practice new ideas. For example, designer Li collaborate with experienced weavers to make round fans (The Great Channel, 2016, 04:25).

In these examples, it is worth noting that designers, design researchers and design institutions have been involved in these examinations and revivals, which ‘update’ the aesthetics while also accentuating the contemporary relevance, value and contribution of the traditions and the artefacts. To understand design’s role in these practices, another round of online research using another search keyword - “craft and design” was employed. Based on the analysis of search results, design’s main contributions are identified as below:

- **Digital Platforms Design:** Dongjia (http://www.idongjia.cn/), Laozihao (http://www.lzhplus.com/#xiazai) and Huaxia Jiangren (http://www.ihxjr.com/start/index.html) are three influential applications and websites in selling craft products and gathering craft-related stakeholders in China. These "intermediation platforms" create a closer interaction between producers (craftspeople) and consumers/users (Jegou et al., 2004; cited in Saikaly & Krucken, 2011). Information about stories behind craft products are offered, including makers' stories, their personal inspirations, production techniques and materials, culture and territory of origin. And some innovative marketing methods like live video streaming, customized service and crowdfunding are adopted to attractive users. In addition, there are many crafts-themed accounts on Chinese social media platforms. These social media platforms have made contributions in sharing crafts-related information as well as connecting different craft communities and individuals. For example, up to 5 July 2019, 317,000 people follow the public page called Craft Revival on the biggest microblogging platform Weibo (https://www.weibo.com/u/3163937325?is_hot=1). And mini-documentary films the Great Shokunin 2 telling crafts people's stories have been watched more than 130 million times on Chinese video sharing platform Youku (China Daily, 2017).
- **Product and Packaging Design:** As one of ten most typical projects promoted by Chinese government (MEPRC, 2017), New Channel design project (http://newchannel.design-engine.org/), launched by Hunan University in Central China, aims to unearthing new opportunities based on local culture and traditions. A co-creation approach is adopted to facilitate the knowledge exchange between the outside designers and local craftspeople (Zhang & Ji, 2016). And many design outcomes with local unique genes have been developed in this collaborative way. For example, in the ethnic group called Huayao in southern China, a series of packaging designs for local specialties and traditional food are developed, and local bamboo, grass and cloth with locally traditional weaving and dyeing skills are used as materials of these new designs (Wang, 2018). Similarly, in southern China, there is an ethnic minority called Dong, and its Dong weaving skill has been recognized as ICH at the national level. A scarf brand combining this traditional Dong weaving skills has been developed (Guo & Ji, 2018). And in Sichuan province in southwestern China, locally traditional stapling skills and lacquer technique are re-used in modern ceramic design (Zhang, et al., 2017).
- **Brand Design:** Norlha is a high-end brand of Yak wool scarves, clothing and other treasures handwoven by nomad on the Tibetan Plateau (https://www.norlha.com/). Sustainability can be seen in many respects. As a "vertical company" with a control of the entire chain, its environmental sustainability is primarily related to the extraction of local raw materials from Tibetan Yaks and its production process with few energy consumption (Yi Xi, 2017, 11:14). Meanwhile, as some local nomads give up herding animals but turn to Yak wool making, to some extent, this change alleviates overgrazing on the Tibetan Plateau (Yi Xi, 2017, 13:14). In addition, social responsibility is correlated with its story-telling way, conveying makers' stories, Tibetan culture and traditions behind the products. For local people, they now "have a steady source of income" in their hometown, so they do not need to work far away

from their family as before. This change is positively associated with locally cultural sustainability, social stability and personal wellbeing (Yi Xi, 2017, 10:49).

5 Discussions and conclusions

As discussed above, craft revival activities and craft-design collaborations in China have made significant contributions to spreading crafts-related information, selling craft products and unearthing new opportunities by inter-disciplinary collaborations. However, in these design interventions, some existing and potential problems which related to sustainability, should be seriously considered. For example, designers normally collaborate with craftspeople to develop new craft products, but there is an imbalanced relationship between them. According to Zhang's research (2016), she critiques that outside designers normally dominate the collaboration, while local craftspeople just act the role of 'manual worker' to achieve their concepts. As a result, in new craft products, local traditions and place-based knowledge which are valued by craftspeople cannot be well conveyed. And for craft e-commerce platforms, economic values are given the first priority, and therefore many mass-produced crafts with affordable prices are recommended on the homepage. In contrast, some culturally significant crafts cannot be well known by online consumers. Obviously, such content designs are used to attractive attentions and stimulate purchases, but in a long term, this design direction may diminish cultural values of crafts. In addition, in the example of Norlha brand, its Yak wool products have been positioned in the "modern luxury market". But as Kapferer and Michaut-Denizeau worry about (2014), "many luxury brands are growing by expanding their operations to low-cost factories, while licensed operators pursue volume and sell fashionable, high margin accessories". This luxury, fashionable and profitable trend may cause big changes in local communities, some potential social changes should be also seriously considered.

It is notable that a common trend in global craft sector is being influenced by modern market and being re-shaped by technology, which is similar to it in Chinses craft sector. Self-enhancement values and openness to change values are encouraged by consumer capitalism and modernism. Luxury and fashionable products, which emphasize on social status, wealth and personal image, have gained considerable traction. Influenced by this, there is a trend that craft objects as fine arts has become popular (Crafts Council, et al. 2012, p47). "Expressive values", like originality and self-expression, are conveyed by many contemporary crafts. And meanwhile, with a continued emphasis on technology, innovation and breaking new ground, there are plenty of technology-dependent craft designs happening today. According to Yair's research (2011), innovations in five terms, including biotechnology, manufacturing, engineering, material, and digital and communication technology are influencing and reshaping the craft sector. However, these trends tend to be dominated by extrinsic values. Opposite to this, self-transcendence values and conservation values embedded in traditional crafts, as discussed above, seem to be largely neglected.

Substantial evidence has shown that extrinsic values are negatively associated with ecological attitudes and behaviors, personal well-being and social responsibility. Due to these ills, this study questions current design interventions which focus on consumption, rather superficial innovation and profit. In contrast, we argue for a more comprehensive sustainable direction with the respect of local culture, indigenous knowledge, and self-transcendence/intrinsic values.

This paper has contributed to the theoretical understanding between craft and sustainability, categorized current design practices happening in China, identified design's contributions in Chinese traditional crafts revival, and pointed out problems related to sustainability in current design practices in Chinese craft sector. These findings shape a theoretical framework and will inform the next in-depth field research in this study area.

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Crafting Sustainable Value through 'Relational Making': A Case Study – The Porcelain Town of Jingdezhen

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The paper presents a case study on craft and its sustainable value in the porcelain town of Jingdezhen, China. Based on a typology of five values pertaining to craft developed in our previous research, this case study investigates an emerging model of making – a collaboration between local artisans and contemporary creatives – in Jingdezhen and its values and priorities through a four-stage participatory research approach. It is found that this emerging model of making brought a successful revival of traditional porcelain craft to the town while also resulting in tensions and contradictions in values and priorities. Informed by the co-creation workshop and experimental project, we propose that building effective working relations among craft makers, contemporary creatives and place/context will be critical in overcoming current tensions in porcelain production and in creating shared values. Through engaging with literature in the field, we conclude with a concept of 'relational making' to support contemporary craft practices. Emerging models of craft production in China can be strengthened by 'relational making' leading to new, more sustainable directions.

Keywords: craft; making; sustainable value; relational making, Jingdezhen

1 Introduction

In China, many crafts are undergoing significant resurgence and revitalization due to the state's *Intangible Cultural Heritage* initiatives and the promotion of cultural and creative industries (ICH China, 2017; EU SME Centre, 2014). As we found in our earlier research, craft's multiple values are not recognized and sustained at a balanced state in China. This means that the economic benefit of craft is often overvalued while the other aspects of craft's value are to a variable degree underestimated (Zhan and Walker, 2018). Our previous research also suggests that crafts in China are highly commercialized and strongly influenced by cosmopolitanism and consumerism. Different from most craft practices in the UK, they often come under the category of 'industrial craft' – that is, large-scale production that is broken down into many steps, each of which contains its own craft specialism. In porcelain crafts, for example, these steps include material sourcing, shape forming, decorating and firing.

Over the past decade, there has been an increasing number of contemporary creatives (artists and designers) from all over the country and beyond who contribute to traditional

craft communities. They started to live and work in the community and introduced very contemporary ideas and avant-garde approaches. The craft processes which used to be done by groups of local artisans now involve a collaboration with these incoming creatives. As a result, a new model of craft making is emerging from the collaboration between these two rather different groups of people.

Given this, we are especially interested in how traditional modes of ceramic production, which constitute a craft ecology, are being affected by this new model of making. It could mean, for instance, that the distinctiveness of traditional modes becomes lost and the products become more homogenized. Porcelain crafts in Jingdezhen, Central China, is a recognized case that exemplifies how these new influences are changing traditional ways of craft production. This research, therefore, asks,

- How are traditional modes of ceramic production within a traditional craft ecology being affected by this emerging new model of making that include the influence of incoming creatives?
- How might design contribute to protecting the intrinsic value of traditional local artisan practices through creative intervention?

To answer these questions, we focused on porcelain crafts in Jingdezhen as our case study.

The components of this paper include a clarification of how we understand craft and its value. This is followed by a description of the case study in Jingdezhen and its findings, which illustrate how value is being created through the emerging new forms of collaborative making in Jingdezhen. We also discuss the tensions and imbalances that are being revealed among three areas of craft making, namely: craft as an artistic endeavour; craft as a resource for the creative economy, and craft as an important element of China's artisanal heritage. Despite these tensions, however, our findings demonstrate that through these creative collaborations, new, more holistic notions of value are being created. The research concludes with our concept of 'relational making' for the revival and sustainment of traditional crafts in China.

2 Craft, making and sustainable value

Craft is often characterized in terms of its: ecological attributes; connection to localization; exemplification of systemic thinking and its relationship to authentic notions of being (Zhan and Walker, 2017, p.2920). The word "making" is widely used in a Western context and often used interchangeably with craft. "Making" literally means "the process of making or producing something" (OED). "Making" as a topic of discourse and a field of research became increasingly popular with the rise of the Maker Culture and Maker Movement in the UK and US in recent decades (Burke, 2014). It serves as a reaction to the de-valuing of physical exploration and the growing sense of disconnection with the physical world in modernity (Martinez, 2013). An essential characteristic of the Maker Movement is the "do-it-yourself (or do-it-with-others) mindset that brings together individuals around a range of activities" (Peppler and Bender, 2013, p.23). "Making" also has a sociological dimension that recognizes the importance of community building and the collaboration of people. Langlands (2017, p.17) interprets craft (craeft in the Anglo-Saxon text) as skills in terms of the physical, mental skill and spiritual forms. This reflects an ideological root of the Maker Culture in ancient Western origins that regards craft as a complex practice of "knowing and thinking".

However, according to the ideological basis of UNESCO's Convention for the Safeguarding of the Intangible Cultural Heritage, craft also represents a manifestation of traditionally communal and cultural knowledge, practices and values grounded in context and place (ICH, UNESCO). As reflected in contemporary craft practices in the UK, craft is more characterized by its engagement with and innovation in materiality and aesthetics (e.g. Make: Shift conferences and Collect exhibitions, Crafts Council). In the word "making", it often places more emphasis on the aspect of "knowing and thinking" that is often cut off from its context. As Langlands comments, understanding craft in its historical and geographic context, and regarding it as Intangible Cultural Heritage will not "lock down craft practices" into their past, instead it can "help give a sense of way of taking it forward in the future" (Interview with Langlands, February 2019).

Craft in the Chinese context is mostly addressed in relation to heritage, culture, community and fine art while lacking an understanding of seeing it as an epistemic way of "knowing and thinking" (Zhan, 2018). Lacking this understanding of craft is a significant omission. However, neglecting craft's relation to geographic, traditional and cultural context also makes the understanding of craft/making single-sided. Therefore, craft is not fully equated to "making" in Western context, although the terms are used interchangeably. In our previous research, craft was viewed through a systemic lens to be a comprehensive ecology that includes richer meaning than that contained in "making". Craft also has comprehensive values that sustain its ecology.

According to that research, craft contains five values: environmental, economic, social, local-cultural, and spiritual, as presented in Table 1.

Five Values of Craft in Relation to Sustainability		
Extrinsic	**Environmental value**	Eco-friendly materials, production processes, renewable resources-labour
	Economic value	Own consumption, increasing income, commercial use
Intrinsic	**Social value**	Employment, conflict prevention, social equality, community building, social norms
	Local-cultural value	Local distinctiveness, self-identified culture instead of cosmopolitan culture, changing cultural tradition instead of the static
	Spiritual value	Beliefs, faith, sense of being, self-fulfilment through making

Table 1. Values of Craft in Relation to Sustainability (Source: Zhan and Walker, 2018, p.5)

Considering the increasingly recognized notions of holistic sustainability and the complex causes of wicked-problems, we can assume that neglect of any type of values will eventually make craft unsustainable. Some crafts in China are found not to be being revitalized and developed in a healthy fashion. It implies that the economic and social value of some crafts are significant but their local-cultural and spiritual values are at risk; some crafts' local-cultural and spiritual values are retained in practice, but the poor financial situation of these crafts renders their local-cultural and spiritual values unsustainable (Zhan and Walker, 2018, P.17).

Within the system of "industry craft" in China that is strongly influenced by a cosmopolitan culture, it is worth exploring how to balance these values to realize a sustainable state. Built on these theoretical underpinnings, a value-centred perspective was developed to guide through the research into the new model of craft production in Jingdezhen.

3 The Case Study: The Porcelain Town of Jingdezhen

Like Delft in The Netherlands and Stoke in England, Jingdezhen is China's centre of ceramic production and is widely known as the 'capital of Chinese porcelain'. High- quality ceramics have been made here since the 10th century (Jingdezhen Archive) and it was the centre of production of the distinctive blue and white 'Willow Pattern' that was exported to Europe in high quantities during the 17th and 18th centuries. In the 20th century, with investment by the Chinese government, ceramics production was increased via large, state-run, ceramics factories. In the 1990s, these factories were dissolved and ceramic production was continued by a host of smaller, privately run workshops and studios, which attracted artists and designers from around the world. This case study, conducted with various makers in Jingdezhen, looks at the current and emerging model of ceramics production and evaluates it in terms of its values and priorities.

4 Methodology and implementation

4.1 Methodology

Due to the explorative nature of this research, a case study was chosen to investigate values of contemporary craft practice in its real-life settings (Yin, 2004). We are design researchers working in craft, because design has a close relationship and fits well with the "learning by doing" model of craft and its creative nature (Zhan, 2019). In this research, we use design as a method of knowledge generation and intervention. Crafts in China are community-embedded activities and are usually promoted as a field for social welfare and poverty alleviation (e.g. New Channel program of Tong community). In recent years, design research in Western society has also turned to a social dimension where a more "socially-driven" form of design has been constructed through a range of activities and interventions. (e.g. Design Research for Change project). Meanwhile, informed by the collaborative nature of craft communities in China, a participatory co-design approach is employed through a social and cultural lens to investigate craft production and help co-create shared value through intervention.

Therefore, the case was studied through a participatory research approach (Simonsen & Robertson, 2013). Aiming to answer the questions, the research was devised in four stages (Table 2). In the first stage of a scoping study conducted in May and December 2017, ethnographic approaches were used to understand the current state of porcelain production and the issues facing the porcelain community. A co-creation approach was employed in the later three stages conducted in November 2018 (Stages 2-4 in Table 2).

Stages	Objectives	Results
1 Scoping study Semi-structured interviews, observations	To understand the current state of crafts in the community in order to identify problems and opportunities.	• Maps of makers and the place • An emerging model of making identified • Tensions in different directions of porcelain production
2 Sense-making activity Contextual interviews with artisans, designers and artists	To make sense of sustainability, value and crafts to participants, and gain their visions of craft's value and sustainability	• Value perception of makers • Protocols for the co-creation workshop
3 A co-creation workshop Conducted with 25 participants supported by Co-design methods and tools	To test the value typology developed from previous research, and co-design a situated strategy for sustaining the value of porcelain crafts through optimized collaboration.	• A proposed model for co-creating a shared value among makers
4 An experimental project Conducted with an invited group of local artisans and six creatives	To test the propositions of optimized collaboration gained from the co-creation workshop in order to develop strategies to implement the optimized collaboration	• Concepts of 'relational making' for moving craft towards a sustainable future through collaboration

Table 2. The stages of the field research

4.2 Conducting the 4 Research Stages and Data Collection

Data was collected through multiple methods of ethnography and co-design. In the first stage of the scoping study, ethnographic methods (Salvador et al., 1999), in the form of semi-structured interviews and participant observations, were used with fifteen interviewees (i.e. artisans, artists, designers, researchers and members of support organizations). These methods were also accompanied by field notes and comments.

Sense-making (Klein et al., 2006) was used to get to know how different makers (i.e. artisans, artists and designers) understand the value of craft and its relationship with sustainability. This was conducted through contextual interviews in the workspaces of eleven makers (i.e. 3 artisans, 4 artists and 4 designers), where materials, tools and environmental settings were used as prompts to trigger a comprehensive dialogue around the value of their work (Figure 1).

Figure 1. Scoping study and sense-making interviews

A co-creation workshop (Stickdorn & Schneider, 2011) was conducted with twenty participants as an act of collective creativity (Sanders & Stappers, 2008). The goal of this was to co-design a situated collaboration proposition to protect the intrinsic value of craft (Figure 2). The workshop was conducted with tools adapted from various resources (Mazzarella, 2018, etc.). The data from the workshop were then developed into an initial proposition in terms of 'collaboration through immersive making'.

Figure 2. Co-creation workshop and aided tools and materials

As an act of both generation and validation, an experimental practice-based project was employed to test the proposed model of collaboration gained from the co-creation workshop. The experiment was conducted with an invited group of artists, designers and local artisans. The group was subdivided into two teams according to participants' interests. Each team was made up of one designer, one artist and several local artisans. Team 1 (Figure 3a) developed their making project through a strong-tie collaboration with two fixed local artisans, whereas Team 2 (Figure 3b) developed their project through a weak-tie collaboration with artisans to whom they turned when they needed. Team 1 made a series of ceramic vases and Team 2 made ceramic lighting. The goals, contents and form of the making project for both teams originated from the participants' current working schedules and plans and were built on their collective agreement. Participant observation, conversation, and filed notes were used to collect data during the two-week experiment (Figure 4).

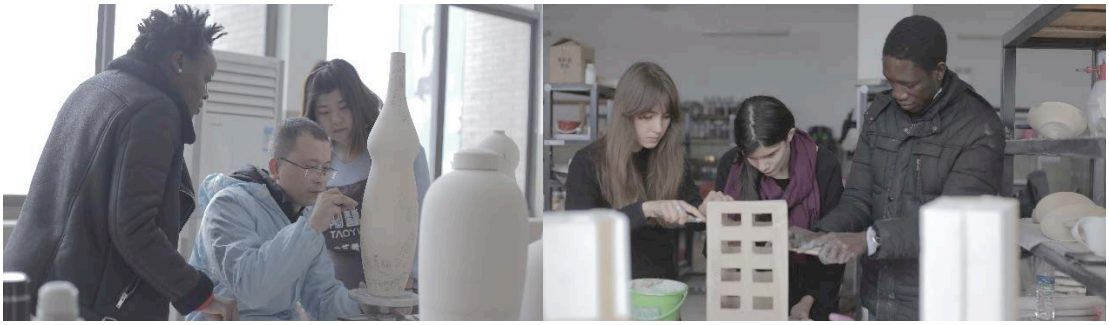

Figure 3a. Experimental project Team 1 *Figure 3b. Experimental project Team 2*

Figure 4. Experimental project

The field data were collected with audio-recording, field notes, notes on given templates as well as photos. After a synthetic processing of the data, they were then thematically analyzed with the aid of mapping and visualization, from which several findings emerged. These findings will be presented and discussed below.

5 Crafting value through collaborative making in Jingdezhen

The porcelain town of Jingdezhen, the case for this present research, is located to the southeast of the Yangtze River Delta (YRD), which is a highly developed and industrialized region of China (Figure 5). Jingdezhen has been producing porcelain and ceramics for over 2,000 years (Dillon 1992).

Figure 5. Location of Jingdezhen in the YRD, China

5.1 Craft revival in Jingdezhen

Porcelain production in Jingdezhen has long been developed into a sophisticated division of skills. However, these complex making processes became industrialized during the era of state-owned factories from the 1950s to the 1990s (Fang, 2015). Since the middle of 1990s when the state-owned factories were shut down, the centralized mass production in large

state-owned factories has been deconstructed and autonomously rebuilt into numerous small specialist workshops by the artisan workers scattered around the old-factory sites and villages (Figure 6).

Due to the flexibility and compatibility of the model of small batch production, the traditional skills have been retrieved and revived in these workshops through reiterative experiments (Interview with Fang, December 2017). The highly skilled artisans and their workshops have then attracted many artists and creatives. Nearly three Thousand people from larger Chinese cities and other countries have moved to Jingdezhen (April 2017, JCFCAA). These, together with local masters and artisans, have formed a new and collaborative community in the historical town. Considering that the two types of people are completely different, and seeing how they work with each other and have brought a revival of Jingdezhen's ceramic industry on such a scale really amazed us.

As the town's structural texture shows (Figure 6), the rational geometric lines intertwine with the organic networks formed by the natural land-water borders, and various clusters of workshops, markets and museums are scattered across the landscape, seemingly without any pre-planning. Jingdezhen's urban layout offers various scales of cooperation for a variety of makers in the town's industrial spectrum - either within the workshop clusters or across many different clusters. It often needs to pass through four or five different specialist workshops for a piece of porcelain to be finished. The re-configurated industrial settings have provided artists, designers and local artisans with a flexible and dynamic space where daily life blends with various work routines, and where tradition meets modernity. This map signifies that the town now stands at the intersection of cosmopolitan and local, modern and traditional, and is facing paradoxical challenges. Now, there are tensions and an imbalanced state of value perception in this collaborative making. This will be presented and discussed below.

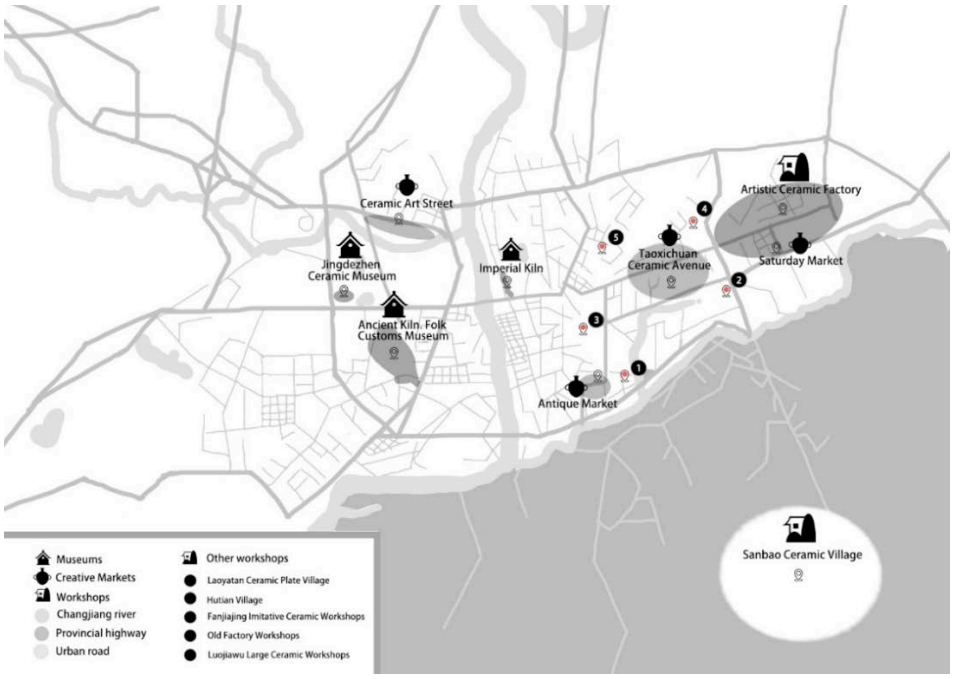

Figure 6. Community map of Jingdezhen © Xiaofang Zhan.

5.2 Makers and their value perception in porcelain making

According to the scoping study, porcelain makers in Jingdezhen fall into four different types: artisans/masters, traditional artists, contemporary artists and ceramic designers (Figure 7).

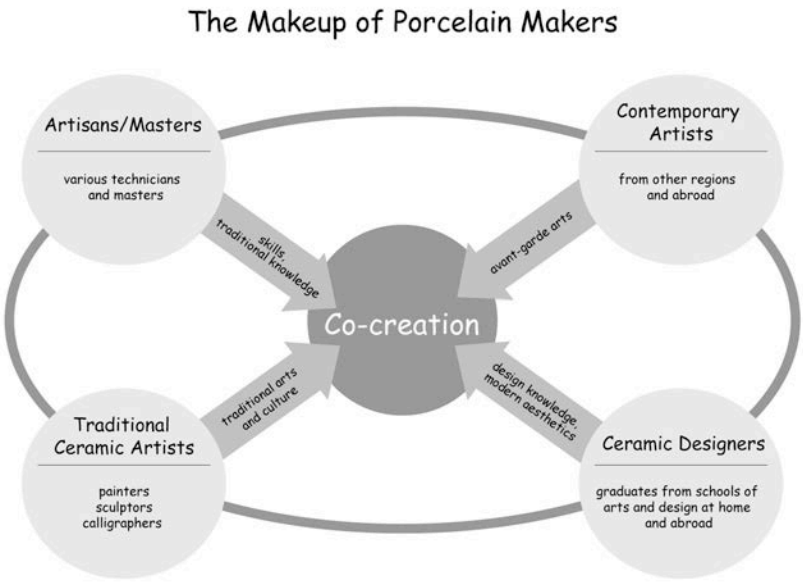

Figure 7. Collaboration among porcelain makers

Different makers have different value perceptions and priorities. Throughout the sense-making interviews, porcelain makers unpacked the concept of value and sustainability within their context. Data from sense-making interviews were analyzed by using a priori themes in terms of five values resulting from our previous research (introduced in Section 3). This led to the identification of subthemes, which were then prioritized according to the frequency of data and are presented in Table 3.

Themes/subscribing makers	Subthemes	Description
Local-cultural value Artisans Traditional artists Designers	Place Identity Tradition Materials Skills/knowledge Lifestyle	Local characters, material, and aesthetics Where I am from, origin, provenance Long-established ceramic history, significant past Uniqueness and local sense of materials Distinctiveness, age-old ways of making Customs and habits of local people
Spiritual value Artisans Traditional artists Contemporary artists	Self-fulfilment Intimacy Ideas/concepts Aesthetics	Self-affirmation in the processes of making Intimacy with materials, tools and environment Creativity of ideas and concepts Beauty that reflects the maker's personal cultivation
Economic value Designers Artisans Traditional artists Contemporary artists	Cultural capital Living basis	From craft as a heritage to craft as a creative asset Livelihood, making a living, survival skills
Social value Contemporary artists Designers	Collaboration Solidarity Equality	Joy of working with others, building relationships A sense of unity, social cohesion through collaboration Increasing employment, no discrimination, artisans are equally respected
Environmental value Designers	Eco-friendly	Clay, traditional processes, one part of natural ecology

Table 3. Themes and subthemes of makers' value perceptions of sense-making interviews

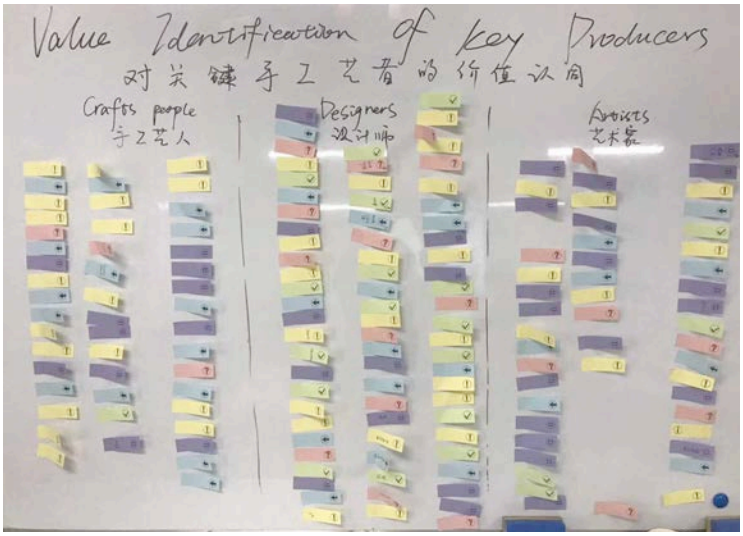

Figure 8. Quantitative data of makers' value identification from the co-creation workshop

Combining the finding from the sense-making interviews (Table 3) and the data regarding value identification from the co-creation workshop (Figure 8), the value perception of these four types of makers were finally identified and are presented in Figure 9. As the figure shows, craft's value relating to local culture and spirituality are perceived as the highest, with the value relating to society the lowest; and porcelain makers were almost unaware of the environmental issue of craft except for the one designer who acknowledged it. It also suggests that the intrinsic value of craft in terms of local-cultural and spiritual are well recognized and perceived by the majority of the porcelain makers. However, craft's social value needs to be made more visible, and there is an urgent need for environmental literacy

education.

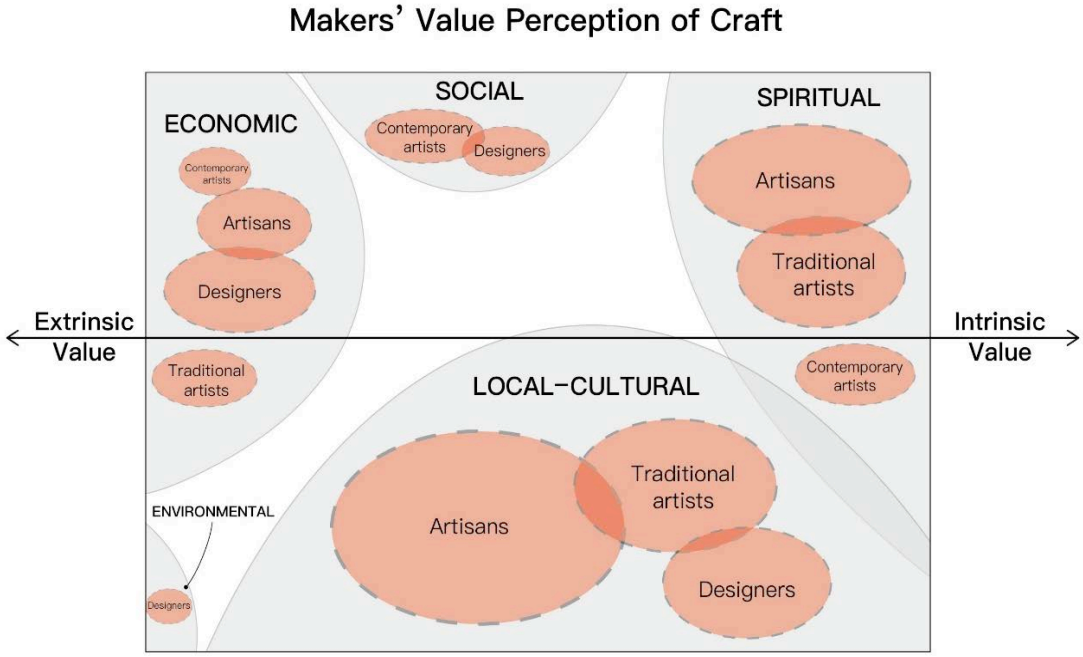

Figure 9. Makers' value perception of craft

5.3 Tensions and imbalances among the three areas of craft making

Porcelain crafts produced in contemporary Jingdezhen cover diverse areas of interests ranging from commercial products to design items and from heritage artifacts to contemporary sculptures. This broad spectrum involves diverse artisans, artists, ceramicists and designers. According to various data from interviews and the different landscapes of porcelain work in the markets, workshops and galleries, three major directions in how makers value craft in their practices were identified:

Craft as artistic endeavour: this direction placed porcelain as constructing arts and novel design ideas led by artists and young avant-garde designers. It includes contemporary sculptures, collectable art pieces, design items. Figure 10 show a representative piece.

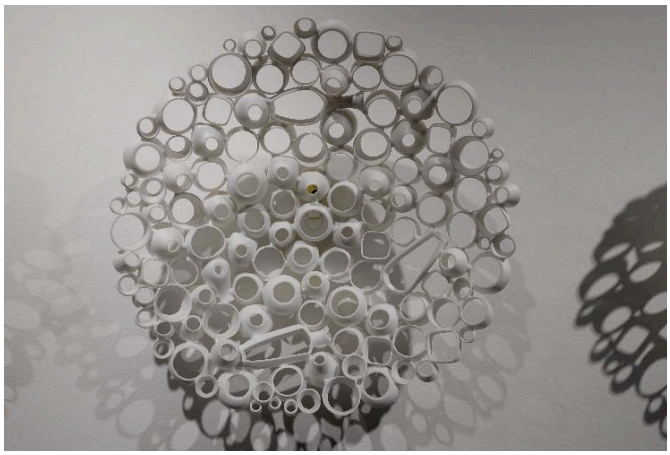

Figure 10. A ceramic art installation in a gallery in Taoxichuan

Craft as a resource for the creative economy: this direction regards craft heritage and craftsmanship as a cultural resource for an economy often led by designers. It includes middle and low-end commercial products, and middle and high-end cultural and creative products, as shown in Figure 11.

Figure 11. Ceramic tableware at a creative market

Craft as artisanal heritage: this direction of ceramic work often reflects a high level of skills, traditional materials' context and meaning, and is a mark of the making process. Most of this type of work is either in a traditional style including everyday use and decorative objects, or modern objects that emphasize the aesthetics of everyday life and simplicity. This direction is often led by master artisans and young ceramic designers or ceramicists. Figure 12 is an illustration of this direction.

Figure 12. A teapot carved with traditional lotus leaves by artisan Mr. Wu

These three directions accurately reflect the makers' different interests and value positions as reflected in Figure 9. Many times, these directions come into conflict with each other, and if any one prevails, the value of the other one or two would be threatened. This will be analyzed below.

On the one hand, if craft is viewed as a resource/asset to generate economic profit, then the artisanal heritage would be at risk. This is because the skills and artisanal knowledge that reflect traditional craftsmanship would be gradually diminished by the increasing demand for the work of mediocre artisans, as the quote states:

> *High-quality products require artisans to invest more time in the making, which also means you need pay them quite a lot of money. Designers need to consider economic factors, so designers turn to artisans who charge less and finish it faster.*

> *The direction of commercial products doesn't need highly-skilled artisans and craftsmanship. This direction is expanding, so the number of artisans with average-level skills is increasing whereas the number of master artisans is decreasing* (Interview with a ceramicist, December 2017).

On the other hand, if the artistic endeavour of craft is emphasized by artists, the traditional skills and knowledge of the artisanal heritage would still not be valued in this community. There is a widely known phenomenon in Chinese ceramic circles that the price and perceived value of a porcelain craft lies mainly in the artistic endeavour made by the artist or the creative ideas by designer. As one informant says:

> *A vase painted by a master artist is sold at a high price, but he just needs to pay much less money to the artisans or the technical masters, compared to the price of the vase. Artists don't actually rely on artisanal knowledge as much as before, because you can just order a batch of very common greenware or plates and paint onto them. Even though it involves substantial work by artisans, the artistry and design creativity dominate the market value of the work. Therefore,* ***many artists and designers have little interest in craftsmanship.***

However, there is a group of makers (mainly artisans and young ceramic designers) who are interested in an artisanal way of making. Their work often reflects a high level of skills, material contexts and meaning, but their work often faces economic pressures and sacrifices in ideas and design, as these two representative quotes states:

> *Everyday use porcelain is not competitive in market…there are many similar products on Taobao [a Chinese shopping platform giant] that are much cheaper. Though they are not handmade, they look even better. So, it is hard for us to sustain. I still think we should carry on with this, though moving away from producing traditional artifacts to making artwork or contemporary design items might change our financial situation* (Interview with ceramicist Mr. Han, November 2018).

> *Artisans can only do their work with the methods they have learned. Many times, designers came up with some new ideas and patterns, but artisans couldn't actualize them, and had little interest in trying new ways even though I encourage them to do so and said I would help them. And designers couldn't make them due to the limitation of their skills. Therefore, designers had to give up or compromise their ideas to fit with the artisans' ways of making* (Interview with ceramicist Mr. Liu, November 2018).

These young ceramicists have to compromise their artistic endeavour to meet the artisans' increasingly declining skills. **Yet, the decline in skills is caused by the very consequence of diminishing interest in artisanal heritage, which is driven by the increasing emphasis over the last few years on artistry, novelty and economics**.

The developing directions of valuing craft merely as artistic endeavour or economic resource is diminishing the value of artisanal heritage. However, sticking to artisanal heritage would make artisans and designers suffer from economic unviability and compromise of their artistry. Therefore, there are strong tensions among these three directions of porcelain production. Central to the tensions is that artisanship and artisans are not valued as before since the directions of 'craft as artistic endeavour' and 'craft as a resource for creative economy' started to prevail, as a result of which collaboration was lost.

5.4 Co-creating a more holistic notion of value through collaborative relationships

As Figure 9 shows, craft's intrinsic value in terms of local-cultural and spiritual value are well-recognized by the majority of makers. However, in contrast to this finding, the tensions discussed above uncover a turn to artistry and economics, and also imply an anticipated detriment to the intrinsic value of craft and its sustainability. In order to address the divergence and imbalance in values, we conducted a co-creation workshop with various makers and people from support organizations. Rather than waiting for external agents of governmental policy or market force, participants proposed to activate a more inclusive and equitable model of collaboration to generate a balanced and shared value among artists, designers and artisans.

Building on the past experience of collaboration, participants proposed an optimized model of collaboration in which artists, designers and local artisans work together in an open, local, convivial and inclusive space to co-create a shared culture and value through negotiation. According to this proposal, artisans who used to work in a sense of 'order production' or 'on-demand' model with artists and designers now equally engage in the whole process while artists and designers also take part in every step of the making processes alongside the artisans.

In order to test this proposed model, we conducted an experimental practice-based project with an invited group of artisans, artists and designers. The group was subdivided into two teams according to participants' interests. One team already had a close relationship and retained this model of intimacy throughout the project, while the other team started with a relatively looser relationship and subsequently failed to build the expected model of collaboration. Through the experiment, important factors for addressing the tensions and creating a shared value in the collaboration are identified:

Building a relationship between people and place through immersive making to strengthen craft's local-cultural and environmental values

Through involvement of all the participants in every process of making in our experimental project, a deep perception and awareness of the local culture and place was fostered, although Team 2 worked in a 'weak-tie' fashion with the local artisans. Working in the original environment generated a deep sense of authenticity and locality. All the participants expressed that engaging in every step of the processes allowed them to look closely at the history and culture of the ceramic industry, and starting with the raw materials made them have a better understanding of the artisans' work. This in turn nurtured a strong sense of environmental stewardship:

> *We were surrounded by clay, porcelain and tools every day, working beside the river and hearing water gurgling and birds twittering. We had never processed clay by ourselves. Engaging in all the processes helps us understand how the clay is sourced and where it is sourced. This brought us close to the site where this material originated, from which we had a stronger sense of the environment, being part of a place and being part of its history* (designer, Team 2).
>
> *I think artisans have a natural relation to the environment and place in which they work. We learned a lot from them in term of environmental awareness. They are not unaware of environmental issues. They actually understand it better and deeper than us* (artist, Team 1).

Blurring space between life and work to create craft's spiritual value

The increasing separation of life and work among the makers driven by efficiency-oriented production greatly impacted their quality of life and well-being. For artisans, this is especially

detrimental. Throughout history, artisans in Jingdezhen shared the role of half-farmer and half-ceramic maker, and their ceramic work was accompanied by their daily farming routine. An artisan in our experiment commented:

> *I used to work in my workshop which was also part of my house. It didn't distance me from my life and made me comfortable. I discussed details with artists who lived in my house. It is interesting that what attracted them most is things from my living room and dining with our family. We enjoyed conversations over a cup of tea in my house. Now I find the same feeling. I think the way we work together in the [experimental]project is relaxing and helpful for us to enjoy both life and work (*artisan Team 1).

In the villages of Jingdezhen, there are many workshops/studios functioning not only as workplaces and stores, but also as homes and living spaces. Through these multi-functional spaces, the connections between everyday life, work routine and business livelihood grow. Makers move across different spaces swiftly and flexibly in a site-specific physical space, along with tourists and customers. Designer Wu says:

> *Customers come and what they see is not only the beautifully packaged ceramic piece in stores, but also how these products are made, what processes it involves, who made them, what the environment and makers' lives are like…These indeed give people a sense of authenticity by which a deep spiritual value of a piece of porcelain is added and internalized.*

Building relationships between designers, artists and artisans through a dialogical negotiation to create craft's social value

How to blend the different types of knowledge and mindsets of designers, artists and artisans in a collaborative design/making process is challenging. While the proposed way of negotiation by engaging the designer, artist and artisan in the same workshop worked throughout the experiment in Team 1, it didn't work in Team 2 even though they also worked together in the same space. The most important reason for the difference, according to observations, is that Team 2 failed to build a space for deeply engaged dialogue among themselves. Dialogue played an important role in integrating these different types of knowledge into a shared outcome by asking what is technically reasonable, economically viable and what satisfies a particular 'aesthetic need'. Master artisan Zhan in Team 1 explains:

> *We discussed while we were making. I think this is the best way. We often came up later with new ideas that actually changed the initial draft they'd designed, because the draft was very limited. We got lots of inspirations when we started to get our hands on the clay, and what we actually wanted just popped up in the dialogue during the process. I don't think it can be fully designed beforehand in the draft and actualized as such. I enjoyed the dialogue and we will continue working together in the future.*

In Team 1's collaboration, the designer gets to know the improvisational nature of the artisan better; the artist discovers the artisan's hidden intuition of beauty; and the artisan accepts more up-to-date ideas and aesthetics from the designer and artist. However, Team 2 failed to develop a shared understanding of each other's knowledge. They worked more in the way of business consultation by asking each other a series of prepared and anticipatory questions, which lacks the quality of a situated negotiation.

By developing a shared understanding through situated dialogues, close social relationships among these different makers are bolstered, rather than through business relations. The accumulation of these close social relationships among makers in turn builds up a greater cohesion in the community. In so doing, craft's social value is created.

Building relations between tradition and modernity through situated design and respectful dialogue to co-create sustainable value

Artisans in Jingdezhen are more rooted in local tradition whereas artists and designers come more from a modern context. They differ in their thinking, knowledge and methodology. Team 1 developed site-specific tools to communicate and design together by presenting together in the workshop. As the last quote by Master artisan Zhan above states, designers' and artists' conventional design and drawing techniques don't work when these different people communicate. The designer in Team 1 gave up their drafts half way and adapted to a way of dialogue aided by non-detailed drawings and onsite materials and examples. The designer and artists in Team 1 reported that the artisan understood their idea very well and gave many suggestions that inspired the ultimate outcome. However, Team 2 stuck to meticulous and detailed drafts and became 'frustrated', as the designer reported, when they found the drafts hadn't been realized by the artisans precisely. Here is representative quote from the designer in Team 1:

> *When we found our accurate drawings didn't work and make sense for the artisan, we turned to using some common words and descriptions we'd learned from artisans before, then some drawings - which don't need to be very precise. The artisan then instantly got what we wanted…* (designer, Team 1).

In this dialogically situated co-design process, respect is vital to gaining empathy and mutual understanding, as the artist in Team 1 reflects:

> *I think the most important is empathy and respect. Before, when I found artisans could not understand my drafts and concepts, I usually thought it might be the artisans' inability to accept modern thinking and ideas, so we needed to help them to change their thinking. Now I realize I am wrong, artisans think with materials and their body, which is more authentic and creative. What we need to do is to learn their language and try to chat with them, and tell them what we think is beautiful... Then, you will find that they understand you and accept your ideas instinctively (*artist, Team 1).

6 Conclusions - The concept of 'relational making'

According to our findings, building effective working relations among craft makers, contemporary creatives and place/context will be critical in overcoming current tensions in porcelain production and in creating shared value. Sennett (2009) criticizes the fact that innovation in capitalist production acts as "a form of individuation and separation", while craft production is closely built on past knowledge and experience within interdependent networks. These networks, as Ingold (2013) argues, are woven through a process of bringing together multiple fields in terms of makers, materials and other non-human elements (including environment). In the process, each field reciprocally communicates and responds to the others. Our findings from Jingdezhen are consistent with these ideas. Our research, especially the final experimental stage, shows the intimacy generated from respectful dialogues and convivial conversations, which arose from an immersive experience in the community environment and its everyday life and culture. These ideas are also consistent with the key concepts of design for sustainability (Zhan, 2017). Both emphasize an interdependence and connectedness among people, environment, society and culture. The new is built upon the old, and innovation upon tradition. Artisans who are rooted in tradition and creatives who represent modernity can work together harmoniously in an open and inclusive space

that combines daily life and work routines. This is not a utopian escape from the current (post-) industrial system, it has been an everyday experience in Jingdezhen over the last decade, as evidenced in our experimental project. Unfortunately, today, these productive relations are under stress because artistic innovation and economic priorities are beginning to eclipse traditional artisanal craft processes. This is especially ironic because the craft knowledge and culture embedded in place are the foundations for the new artistic and designer innovations that are capable of generating new and added value to traditional craft.

However, appreciating the value of traditional craft knowledge, as the experimental stage of our research shows, requires a respectful dialogue with artisans and a deep immersion in the place where this knowledge and artisanal skills have been nurtured.

These findings, which are generally supported by the literature in the field, also resonate with the conclusions that Eyferth draws in his research about the papermaking handcrafts in China. Eyferth (2009) holds that craft knowledge and the ability of makers can only function collaboratively among makers in certain societies and in particular geographic places; once the natural and social relations break, the craft knowledge becomes invalid. This helps explain why Jingdezhen's traditional ceramic production could be successfully revived in such a short period (1990s-2010s). Despite major systemic changes due to state factory closures, the geographic and social relations of the ceramic practices were fully broken and were able to survive into the post-state-owned factory period.

These findings reinforce understandings of craft and craft knowledge as ecological and social rather than individualistic. Craft knowledge is built in a particular ecology in which particular people and materials constantly respond to each other. This contributes to a sense of place as well as a sense of distinctiveness (Walker et al., 2018). These understandings led us to see contemporary craft practices as a form of '**relational making**', as opposed to an individual endeavour, which is often the case in Western society. By 'relational', we do not mean the kinship that is constructed through descendency centered on lineage, even though historically such lineage was an important aspect of China's traditional crafts (e.g. Fei, 1992; Li, 2017). The 'relational' idea we employ here refers to the inter-reliance and connections among artisans, contemporary creatives and place. These interdependencies and connections can only be built in a specific space where situated and respectful dialogues can occur.

This paper has discussed value imbalances and tensions within an emerging model of craft making in Jingdezhen that brings together traditional artisans with contemporary creatives. It has proposed an approach we have termed 'relational making' to address these challenges. Our findings suggest that engaging in 'relational making' can be helpful in generating shared and sustainable value amongst disparate people within a divided production system. We believe it has great potential to weave together contemporary and traditional elements into an innovative and creative production system of 'industrial craft'.

The increasing natural and social crises in recent years have demonstrated that Western-style production-oriented approaches are incapable of tackling the increasingly wicked problems caused by these forms of production, and new directions must take

into consideration what are fitting to place and context. Thus, future approaches will not be a one-size-fits-all approach (Sheehan, 2011, p.70). As we have mentioned, we understand craft/making not only as a practice that manifests traditional, communal and contextual knowledge, but also as a way of 'knowing and thinking'. Adamson (2010) suggests that, apart from being seen as a field of making, craft can also be understood as an idea that can contribute to theory building. Emerging models of craft production in China can be supported and strengthened by 'relational making' leading to new, more sustainable directions. For these reasons, the concept of 'relational making' is worthy of further exploration.

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Demonstrating a new approach for personal and digital fabrication of moulded pulp products

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In this paper, we demonstrate an approach for designing 3D printed porous moulds, which can be used by individual to create moulded pulp objects of desired form. This approach requires user to provide simple partitioning of the 3D digital model for the moulded pulp object, and then apply program scripts on a 3D modeling software to generate elements of a porous mould which can be 3D printed with low-cost desktop 3D printers. Indeed, the entire process (from mould design till production of moulded pulp object) can be done at home or in makerspaces with 3D printers. The significance of this paper is on demonstrating feasibility of small-scale production of moulded pulp objects, without relying on expensive industrial manufacturing facilities as in conventional approach. This opens up the possibility for individual designers to experiment with moulded pulp products, thereby allowing them to get feedback for enhancing their products and possibly scale up their production volume.

Keywords: moulded pulp, digital fabrication, porous mould, 3D printing, parametric design

1 Introduction

Moulded pulp product (MPP) is a general term used to describe product which is made from pulp or fiber through moulding, with egg tray as the most widely known example. According to International Molded Fiber Association (IMFA) (2019), MPPs are being used for food related packaging, industrial or engineering packaging, single medical use and horticultural tray and pots. As MPPs are made from cellulose, they are totally renewable and biodegradable, and demands are increasing due to the sustainable nature of the product. Didone et al (2017) gives a comprehensive review on history, applications, processes, tooling, mechanical properties, and environmental impact of MPPs.

However, existing approaches in manufacturing MPPs involve use of metal moulds and porous materials, vacuuming and intense temperature and pressure with specialized industrial machines (Didonet et al, 2017), which are difficult and expensive for individuals to create MPPs in small quantities. With abundance supply of paper pulps from waste paper around us (including newspaper, books, magazines, office papers, cardboards and even drink cartons), it will be beneficial to have an approach which allows us to produce MPPs without need of accessing these specialized tools and environment. This facilitates individuals in exploring innovative use of waste paper, and encourages their local recycling, thereby promoting sustainable development in cities.

In this paper, we demonstrate a newly developed approach on using 3D printed porous moulds for creating MPPs. This approach requires access to 3D modelling software (Rhino 3D modeller (www.rhino3d.com) in our current study, but can also be other computer-aided design software which supports boundary representation and scripting for parametric design), 3D printers, and conventional tools which can be found in household or makerspaces. The motivation for developing this approach is to enable production of moulded pulp objects through digital fabrication (Gershenfeld, 2012), so that the approach is accessible to individuals without need of specialized tools. This approach is still a work-in-progress, and we expect to report further refinement in coming future.

2 The Approach and Preliminary Results

2.1 Overview of Process and an Example Mould

According to Didone et al (2017), the entire process in manufacturing MPP includes:

1. mixing - mixing paper with water and add additives to prepare pulp with desired consistency
2. forming – shaping pulp by custom designed tools through vacuuming
3. pressing and drying – wet part from step (2) is moved to a heated mould which is then compressed to improve surface smoothness, dimensional accuracy and mechanical strength
4. trimming and quality inspection

Step (3) requires moulds which can tolerate heat (from 100°C to 350°C) as well as pressure (from 3 to 8MPa), and are usually made from metal in production to improve durability. While this step is important in improving smoothness, dimensional accuracy and mechanical strength, facilities for carrying out this step is not easily accessible by individuals.

Our approach follows a similar process, but combines Steps 2 and 3 with the use of 3D printed porous mould which can be fabricated with 3D printers. Figure 1 shows different parts of a 3D printed porous mould, which is used to produce the MPP in Figure 2. The mould consists of three parts, and are put together by bolts-and-nuts so that pulp inside can be compressed while drying, thereby increasing the strength of the resulting MPP.

Figure 3 shows a cross-sectional view illustrating how the three parts of the mould are put together. The red one is the top mould, the purple one is the middle mould and the green one is the bottom mould. Note that the middle mould acts as a “guide” along which protruding part of the top mould moves. The cavity bounded by the three parts of the mould are for filling the pulp, and pressure is exerted onto the pulp by pushing the top mould through tightening the bolt-and-nut on the four corners of the mould. The protruding part is slightly smaller than the “guide” (with a gap size of 0.3mm as shown in Figure 3) to allow it to move along the “guide”, but yet large enough to avoid paper pulp from leaking out while compressing the pulp.

The mould is printed with a low-cost FFF (fused filament fabrication) 3D printer using PLA filament, and each mould consists of holes in three orthogonal axes, with each hole having a radius of 0.8mm. Those holes are for draining water when the pulp is compressed, and for water to evaporate while the pulp inside is drying under pressure. The radius is being

selected due to limitation of the 3D printer, as the nozzle size of the printer is at 0.4mm diameter, and holes with radii smaller than 0.8mm cannot be reliably printed. Smaller holes can be achieved with different configurations (e.g. using smaller nozzle size) and printing technologies (e.g. stereolithography and selective laser sintering). For example, we have used a Form 2 3D printer (from FormLabs, formlabs.com) using photo-polymerized resin to achieve a hole size of 0.35mm radius.

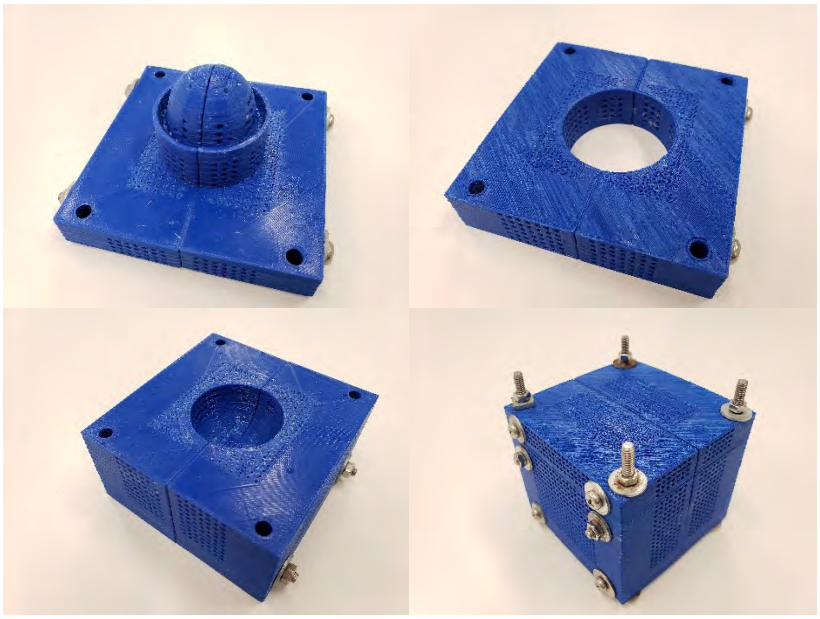

Figure 1: Three parts of the mould: top mould (top-left), middle mould (top-right), bottom mould (bottom-left); the three parts of the mould are put together with bolts and nuts to form the complete mould (bottom-right).

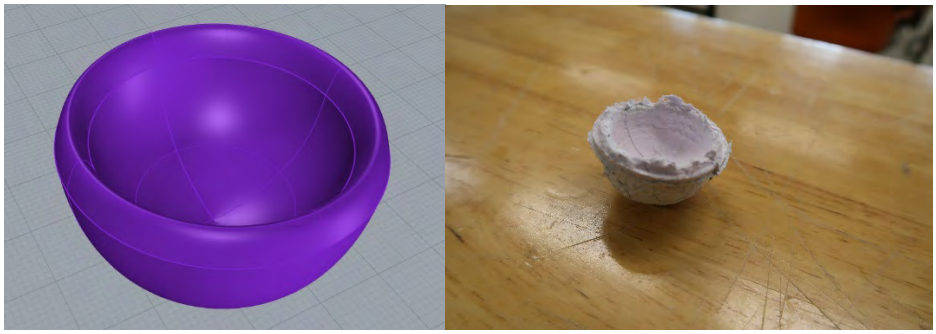

Figure 2: The model (a simple cup) of the moulded pulp object for demonstration of the process (left), and actual object being moulded (right).

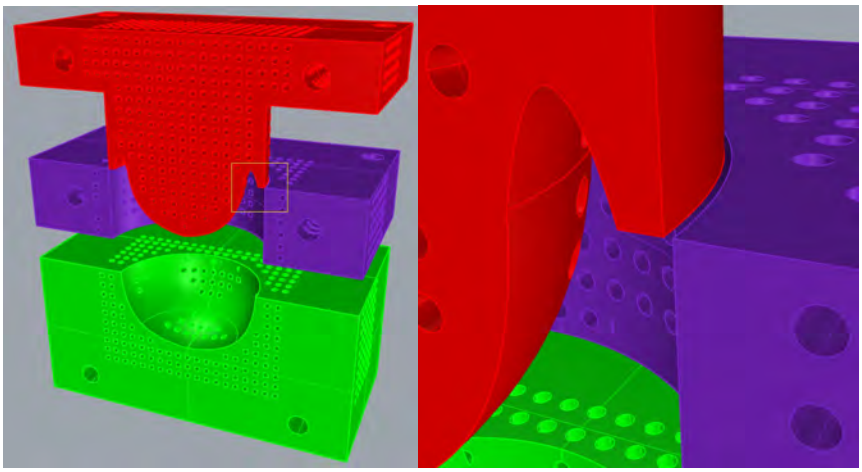

Figure 3: Cross-sectional view of the complete mould, showing how three parts of the mould fit together (left). Zoomed view of the yellow box on the left image shows the gap between the top mould and the middle mould, which measures to 0.3mm (right).

In the section 2.2, we will walk through the detailed steps to create a moulded pulp object with the above 3D printed porous mould. Then in the section 2.3, we will briefly talk about how the mould is being designed through parametric approach.

2.2 Fabricating Moulded Pulp Object with 3D Printed Mould

The following is the detailed steps to create an MPP with a 3D printed porous mould. The steps are as follows:

1. Waste papers and envelopes are teared up into small pieces and mixed with water for preparing pulp (Figure 4). Pound the mixture until they break down into a pulp.

Figure 4: Teared up paper and envelope in water

2. Pour the pulp into the mould (Figure 5). Note that the one on the left consists of the middle and bottom moulds. After pouring the pulp, the top mould is pressed onto the pulp to squeeze out as much water as possible. As water in pulp cannot be drained out entirely by just applying pressure without drying, more pulp have to be added and then squeezed, so as to increase the density of paper fiber in the resulting MPP. Note that the compressed pulp at this phase should have a larger volume than the desired one, which allows for further shrinkage while drying.

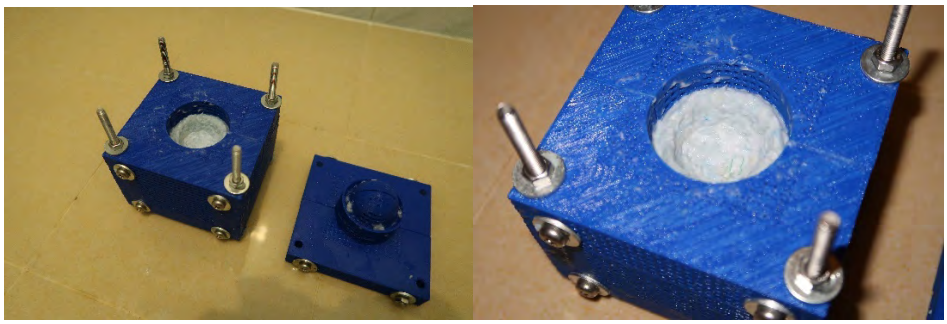

Figure 5: Pulp is poured into the cavity formed by the middle and bottom moulds, and compressed with the top mould (left). Close-up view of the pulp in mould after compressing (right).

3. After putting enough pulp inside the mould, the upper mould is put on top of the lower and middle moulds, and bolt-and-nut on four corners are tightened to maintain pressure on the pulp. The entire pulp is either being dried in open area, or put into a temperature-controlled oven at about 50°C. We called this the "1st phase drying", and the purpose is to allow the pulp to dry up to a reasonable level so that the pulp can be removed from the mould for the "2nd phase drying" in Step 4.

   Drying in open area will take longer time (about 1 or 2 days), but this will not degrade the mould which is printed with PLA. Applying heat to the pulp helps to speed up the drying process, but doing so will degrade the mould. In fact, PLA tends to break down at temperature higher than 60°C (Zhang, et al, 2008), and hence it is not preferred to heat the mould at temperature higher than 60°C. Another concern is the "Heat Deflection Temperature" (HDT), which corresponds to the temperature at which PLA deforms under a specified load. For PLA, HDT is at 49-52°C at 0.46MPa. As the mould is exerting pressure onto the pulp, it is important to use an appropriate temperature to reduce deformation of the mould due to heat. Hence, we set the temperature at 50°C, and keep that for 2 hours.

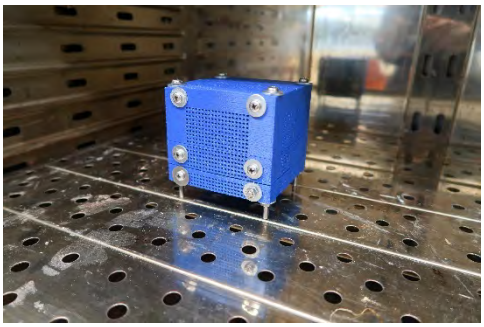

Figure 6: Mould with pulp (while under compression) is heated in temperature-controlled oven at 50C for 2 hours.

4. After the 1st phase drying, the pulp has substantially reduced its water content and easier to hold its own shape, and can be removed from the mould. The mould is designed in such a way that each part can be split up into two halves, so that the pulp (while still wet) can be removed from the mould (Figure 7). Note that the pulp is still wet and can be deformed by exerting pressure onto it.
   The pulp is then gone through the "2nd phase drying" in a temperature-controlled oven at 140°C for 2 hours (Figure 7) to remove excess water from the pulp to arrive at the final MPP.

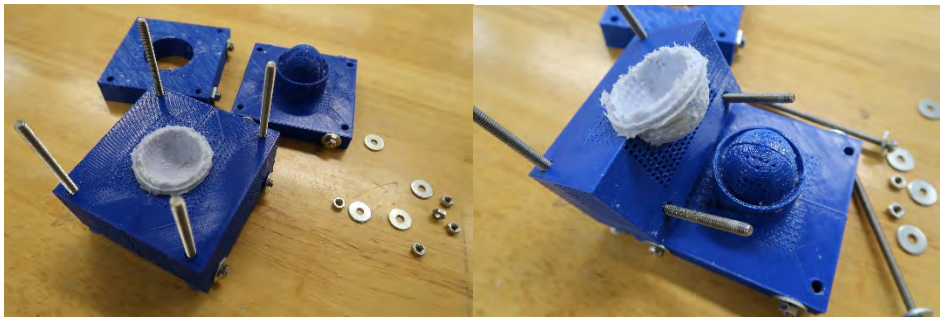

Figure 7: Remove MPP (not entirely dried) from mould after 1st phase drying

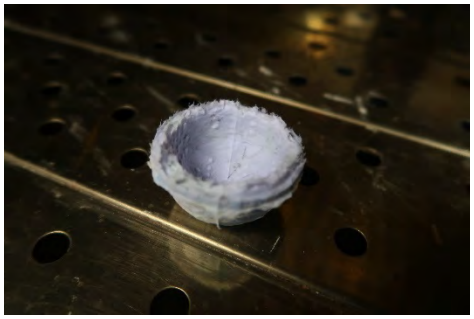

Figure 8: MPP (not entirely dried) is heated in temperature-controlled oven at 140C for 2 hours

2.3 Mould Design through Parametric Approach

Designing an appropriate mould is a very important step in moulded pulp production. In order to simplify the entire process in designing a mould, we developed a number of scripts running on Rhino 3D modeller (www.rhino3d.com) for generating different parts of the mould. The steps in mould design is as follows:

1. Create a 3D model of the object to be moulded. One can refer to Figure 2 as an example.
2. Partition the model into three parts: lower model, upper model and lower negative model. Figure 9 helps to visualize the three parts, based on the one in Figure 2.

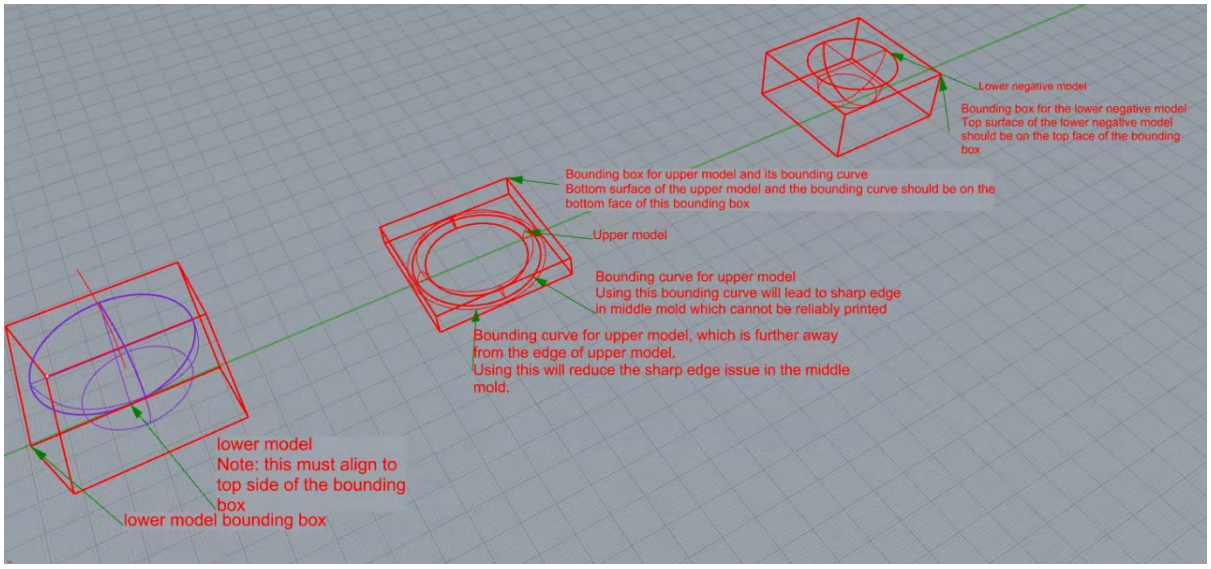

Figure 9: Decomposition of the model of the object to be moulded into three parts: lower model, upper model and lower negative model

3. By using the three partitioned models together with some other geometries as shown in Figure 9 (including bounding curves and volumes of the corresponding 3D models), a script in Grasshopper (a parametric design plugin in Rhino 3D modeller) is executed to generate a number of 3D objects and reference points as shown in Figure 10.

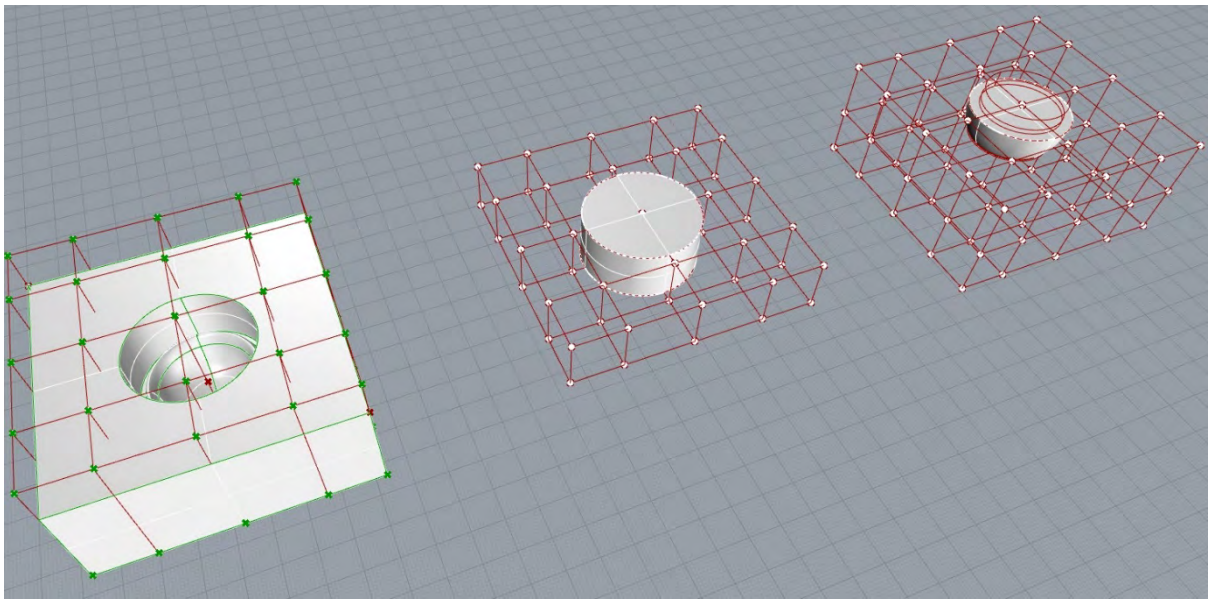

Figure 10: Three sets of objects and reference points generated by a Grasshopper script. These are for generating different parts of the mould, and they correspond to (from left to right) top, middle and bottom mould.

4. Each set of geometries in Figure 10 is used as input to a program written in PythonScript under Rhino 3D modeller to generate holes (cylinders to be exact) along three axes. Figure 11 shows the corresponding part of the mould (half of each mould) being generated. Briefly speaking, the part of the mould being generated is the “negative” of the geometry in the corresponding set of the objects in Figure 10, and then cylinders are removed in the resulting part.

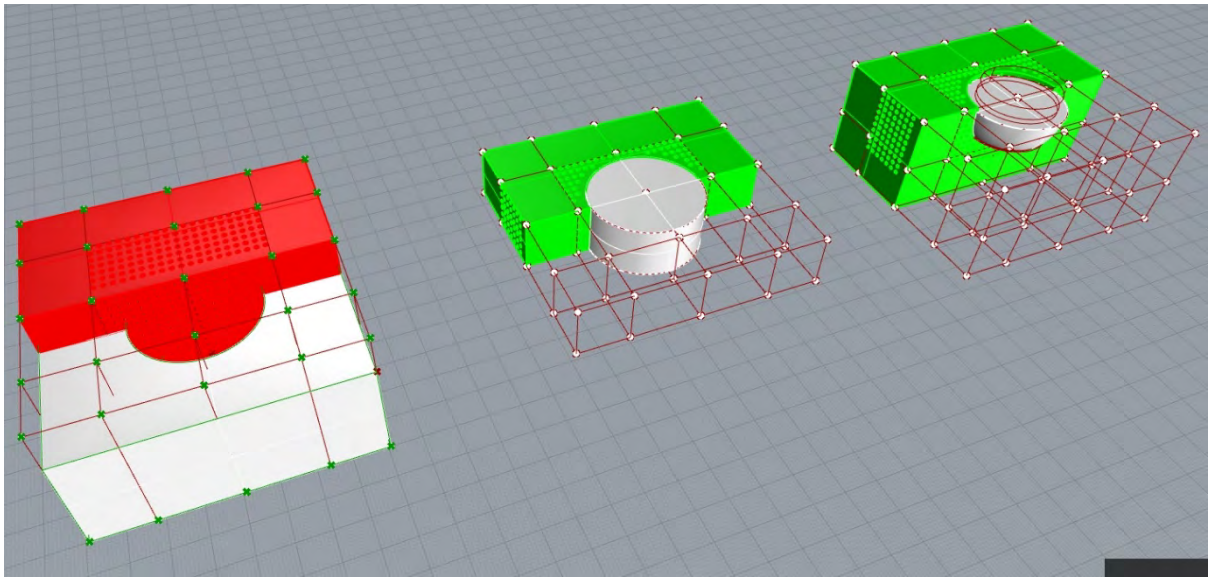

Figure 11: Half of each part of the mould being generated by the PythonScript program in Rhino 3D modeller, based on geometries in Figure 10.

5. Additional holes are then added for inserting bolts for aligning different parts of the mould, and the mould can then be used for fabricating MPPs.

3 Conclusions

This short paper demonstrates a process in creating moulded pulp products using 3D printed porous mould. The entire process requires 3D modelling software and 3D printers, as well as simple household tools like screwdrivers and pliers, and optionally temperature-controlled oven. In fact, the entire process (including mould design, fabrication and moulded pulp products fabrication) can be carried out at home or in makerspaces with simple tools and 3D printers. This allows individuals to manufacture customized MPPs in small quantities, and allow them to explore and evaluate innovative applications of pulps, especially those extracted from waste paper, which are abundant in cities.

We are still in the process of refining our approach, especially on scripts for assisting individuals to create moulds. For example, we are working on a Grasshopper script which allows user to define their parting line of the mould instead of partitioning the mould in a uniform manner. Also, the computational efficiency of the program in PythonScript for generating holes can be improved, so that more holes can be generated. The surface finishing of the moulded pulp object is highly affected by the quality of the moulds, especially on the hole size. In fact, small number of holes lengthens time to dry, and while large hole size leaves visual artifacts on the moulded pulp objects. Hence, it is desirable to have smaller hole size and more holes. In this paper, we reported using PLA for 3D printed porous mould with a hole radius of 0.8mm, which can still be fabricated by using FFF 3D printer with smaller nozzle size (e.g. 0.1mm nozzle, but with longer printing time) or using other 3D printing technologies like SLA (stereolithography) or SLS (selective laser sintering). For example, using the Form2 SLA printer (from Formlabs), we manage to print holes of radii at 0.35mm reliably. In fact, with the rapid advancement of desktop scale 3D printers, we can expect to be able to fabricate porous moulds with smaller hole size with lower cost machines, thereby improving the visual quality of the moulded pulp object.

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Designing Parametric Matter

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This paper presents a series of design experiments that seek to move beyond today's computer-aided design and computer-aided manufacture (CAD/CAM) technologies and investigates alternative material practices based on programmable self-assembly. When using CAD software, 3D designs can be rendered extremely flexible and adaptable such that changes to an objects size, colour, transparency, topology, or geometry can be made quickly and easily. However, once digital designs are converted into physical objects via typical CAM technologies, this capability for adaptation usually dissolves as objects are typically fabricated using inert materials and no consideration of a material's computational abilities. The series of design experiments discussed in this paper help to rethink and re-imagine the possibilities of design and making with adaptive fabrication processes. The design experiments explore mineral accretion and generative paint recipes. Mineral accretion is predominantly controlled via a process of electrolysis to produce adaptable crystal structures that are grown on cathode scaffolds within a volume of seawater. The generative paint experiments expand on the mineral accretion work to explore how material self-assembly can be guided using less restrictive scaffolds. The experiments reveal how 'contrast' can be exploited within the design process as a means of guiding and monitoring material scale self-assembly. Through reflection of these material experiments, this paper seeks to provoke discussion about the role of design within future manufacturing systems, and the possible physical properties of future designed objects.

Keywords: Programmable self-assembly; Parametric design; Adaptation; Tuneable environments; Interrelationships; Contrast; Mineral accretion

1 Introduction

Computer-aided-design (CAD) tools have changed the way we design a wide range of physical objects, from the scale of buildings to medical implants. Key to this transformation has been the ability to quickly model and reconfigure 3D designs based on sets of parameters (e.g. the depth of a steel beam being calculated as a function of its length). This form of associative 3D modelling using parameters is often called "Parametric Design" (Jabi, 2013) and has been especially significant within architectural design (Burry, 2011; Schumacher, 2009a, 2009b). The power of parametric design is that it allows 3D structures, shapes, geometries and volumes to be continually manipulated in real-time based on complex relationships with predefined numerical parameters. In an architectural context parametric design enables: (a) real-time feedback between design decisions and physical

properties (i.e. aesthetics, material properties, function) (Bhooshan, 2017; Burry, 2003; Jabi, 2013; Leach, 2009; A Menges, 2012a; Woodbury, 2010); (b) description of increasingly complex geometric structures which can be structurally efficient and ornate (Block, 2016; Colletti, 2010; N Oxman, 2010a, 2010b; N Oxman & Rosenberg, 2007; Richards & Amos, 2015) (c) digital fabrication instructions / processes that can be produced directly from model data for robotic tools or units (Aejmelaeus-Lindström, Willmann, Tibbits, Gramazio, & Kohler, 2016; Dunn, 2012; Gramazio & Kohler, 2014; Keating, Leland, Cai, & Oxman, 2017; Achim Menges, Sheil, Glynn, & Skavara, 2017; Stuart-Smith, 2016; Willmann et al., 2012).

Indeed, much has been written about the impact that flexible parametric models have had on contemporary design practice (R. Oxman, 2006). However, a fundamental challenge remains that this flexibility only exists within the digital representation of the design, and is severely diminished or destroyed when objects are fabricated and brought into the real-world. The question that motivates this research is: *how can this capacity to adapt be programmed directly into the physical materials themselves?*

“Persistent Modelling” (Ayres, 2012b) is a research agenda that challenges this physical fixation. In persistent modelling, the relationships between the representational mediums of the designs processes (sketches, models, digital models) and final physical objects are emphasised and ‘persist’ throughout the lifetime of the object. The relationships between the two allow for time to be accounted for, so that change can occur via feedback between the digital design representation (e.g. the parametric model) and the situated physical structure. For example, Ayres (2011), demonstrates this concept by creating a real-time link between the parametric model and material by inflating metal sheets.

In this paper, we build on the persistent modelling concept by incorporating self-assembling materials. The key contribution of this paper is to synthesise and reflect on three-years of design experiments, which have set out to investigate how insights from domains of chemistry, materials science, and artificial life might help us imagine ways of growing physical structures with adaptive fabrication processes.

In these experiments, growth processes are guided and “tuned” in real-time through environmental stimulus, specifically electrical current but, pH, temperature and salinity can also be used to tune material properties. These environmental stimulus form 'tuneable environments', which are a set of physical stimuli that are adjusted via digital design tools to alter the conditions of a volumetric space that contain self-assembling materials. This paper aims to synthesise the lessons learnt and reflect on the key challenges and opportunities for designing with adaptive materials, as technical details are presented previously (Blaney et al., 2015; Blaney et al., 2016; Blaney et al., 2017).

The paper is structured in three sections. Firstly we contextualise the concept of programmable self-assembly via adaptive materials to illustrate the rich history of these ideas within architectural design and also point to potentially valuable areas of research that lie outside of design to highlight synergies and challenges that can be addressed by integrating digital strategies with self-assembly. Secondly, we present the design experiments in the style of an annotated portfolio (Gaver & Bowers, 2012), focusing less on the technical details of experiments, but instead on the material properties of the volumes grown. Finally, we reflect on the lessons learnt, and outline key challenges and opportunities for designing with adaptive materials.

2 Background

Parametric design has strong roots within architectural design as a means of generating and informing 3D designs both via analogue and more recently through digital processes (Bhooshan, 2017; Schumacher, 2016; Wiscombe, 2012). The physical form finding experiments developed by Frei Otto (e.g. using soap film models, woollen thread models, magnetic needle models) (Vrachliotis, 2016) and Antoni Gaudi's Catenary string models can be described as analogue parametric models (Burry, 2016), used to help generate exemplary architectural designs. Both Otto's and Gaudi's parametric models' setup conditions (i.e. a physical framework comprising of dimensions, tension, voids, boundaries) directly generated material forms and properties in response to these conditions.

The reason we can consider these early form finding experiments as analogue parametric models is because in these models the 2D patterns and 3D forms generated are: 1) inherently linked with the properties of the materials used and 2) use inherent material tendencies to self-organise forms when physical forces are imposed upon them; notably it can be argued that these sort of models perform “material computation” (A Menges, 2012b).

One of the major downsides of these analogue parametric models is that the process of generating and evaluating designs can be time consuming. Digital parametric models address this problem and make it possible to re-create aspects of these analogue parametric models using computers, which enable the designs' to be digitally transformed easily on the fly (Bhooshan, 2017; Burry, 2003; Jabi, 2013; Leach, 2009; A Menges, 2012a; Woodbury, 2010) along with the ability to monitor properties and determine desirable design features.

Whilst digital parametric models offer advantages in terms of speed, they also lose some of the richness of analogue form-finding models of Otto and Gaudi. Specifically:

- All associations between material, geometry, forces need to be explicitly and manually defined by the designer prior to digital form finding strategies. This imposes a limit of the ‘scalability’ of such methods, in that extremely complex conditions and associations require both significant time to setup, and computational power to process (Harding & Shepherd, 2017; Richards & Amos, 2016).
- Digital parametric models tend to assume perfectly uniform and homogenous materials that are crude abstractions of the materials found in the real-world (Michalatos & Payne, 2013; Richards & Amos, 2016).
- Due to the need to work with relatively simple parametric associations in digital models, and use rough abstractions of material properties, there is often a severe ‘reality gap’ or disconnect between digital models and the fabricated models. Notably, this gap occurs because there is no direct feedback between the physical and digital (Ayres, 2012a).

To address these challenges, a variety of approaches have been explored. These include, developing new digital representations of heterogeneous materials using volumetric pixels (or “voxels”) (Doubrovski et al., 2015; N Oxman, 2010a, 2010b; Richards & Amos, 2015, 2016); and use of bottom-up generative processes to eliminate the need to pre-parametrise all associations manually (Oxman & Rosenberg, 2007, 2007a, 2007b; Richards & Amos, 2015, 2017).

These approaches, whilst significant, retain a disconnection between the physical and digital models. That is, the adaptive capacity of the digital model is destroyed as soon as the

physical design is constructed. Meaning the corresponding physical models cannot alter their material properties based on data, designed logics or relationships present within the digital model after they have been fabricated. Conversely these such adaptive abilities are universally present within biological processes of fabrication and structures (often cited as a key inspiration behind such designs), which have the ability to physically tune and adapt their properties across scales as design demands change (N Oxman, 2012; Speck, Knippers, & Speck, 2015), a feature which is particularly evident in bone-remodelling (AMGEN, 2012). These processes and enhanced abilities are the inspiration for rethinking how artificial materials can be interacted with throughout fabrication processes.

To address this challenge, “Programmable Matter” and “Persistent Modelling” are research areas that reconnect design representations with their physical counterparts to enable a richer connection between the two worlds, and the capacity to create adaptive physical designs. Critically, combining these two worlds could pave the way towards a future where structures may transform on-demand, reconfigure, self-heal, self-assemble and adapt.

One approach to producing programmable matter is called 4D printing (where the 4th dimension is time). In this approach, objects can be 3D printed in one shape, and transform into another programmed shape after being fabricated in response to specific environmental stimuli (e.g. pressure or heat). (Correa et al., 2015; A Menges & Reichert, 2015; Raviv et al., 2014; Reichert, Menges, & Correa, 2015; Tibbits, 2014a, 2016; Tibbits, McKnelly, Olguin, Dikovsky, & Shai, 2014; Wood, Correa, Krieg, & Menges, 2016).

A second approach utilises self-assembly and embeds information into the material components themselves, by designing their geometries and connection interfaces (Papadopoulou, Laucks, & Tibbits, 2017; Tibbits, 2012a, 2014b, 2016). The key idea with self-assembly is that in much the same way as the early analogue form finding experiments of Otto and Gaudi, whereby simple components respond to environmental stimuli and organise themselves into useful structures. The primary benefits of self-assembly that are of interest are:

- Materials can reconfigure and transform their structures when supplied with energy (Papadopoulou et al., 2017; Tibbits, 2012b; Tibbits & Flavello, 2013).
- The designed interfaces can result in self-error correcting construction methods (Papadopoulou et al., 2017; Tibbits, 2011, 2012a, 2012b).
- Scalability, as the fabrication is a bottom-up process based on the material components' interactions.

An exciting aspect of this approach is that the process reveals a space between deterministic and non-deterministic fabrication processes, which can produce surprising and often desirable outcomes that were initially not conceived by the designer (Tibbits & Flavello, 2013). This resembles Otto's work of setting up conditions and trusting materials to compute sophisticated and desirable forms. Currently, the use of and supply of energy to these programmed material components is limited (Papadopoulou et al., 2017; Tibbits, 2014b) and provides little feedback. However, it is a significant mechanism and plays a large role in the fabrication process and as Tibbits (2016) has noted is needed to achieve self-assembly. Related work outside of architecture has also been demonstrated that various intricate 3D forms can be grown at the microscale by varying the pH during crystal growth (Grinthal, Noorduin, & Aizenberg, 2016; Kaplan et al., 2017).

Persistent modelling is slightly different as it seeks to bridge the gap between digital and physical models by using feedback of physical stimulus (e.g. pressure) to inform digital models, which then inform the physical models. In this system, the stimulus acts as the energy that informs material deformations. The benefit of this is that the stimulus can be mapped to a relevant design demand and or logic that informs material manipulations (e.g. structural requirements or solar shading) (Ayres, 2011). The reconnection between digital model and physical model enabled by persistent modelling highlights two factors of interest, time and complex material behaviours, however, as the authors have previously demonstrated, the incorporation of material self-assembly extends these abilities and raises several other exciting factors and challenges.

3 Explorations in Parametric Matter

We now describe a series of design experiments that aim to expand the notion of persistent modelling by incorporating self-assembling materials. We first provide a brief description of each of the processes used and key findings, before reflecting on the series of experiments as a whole, in the form of an annotated portfolio (Gaver & Bowers, 2012) to highlight key themes, challenges, and potential impact on future design roles. Figure 1 shows a collection of prototypes developed over 3 years, which explore and develop the idea of tuneable environments as a fabrication strategy, which addresses subsequent challenges and consequently raises new ones in regards to informing properties of the materials grown using the mineral accretion process. The prototypes build towards and adaptive design and fabrications system that can manipulate variables of the mineral accretion process.

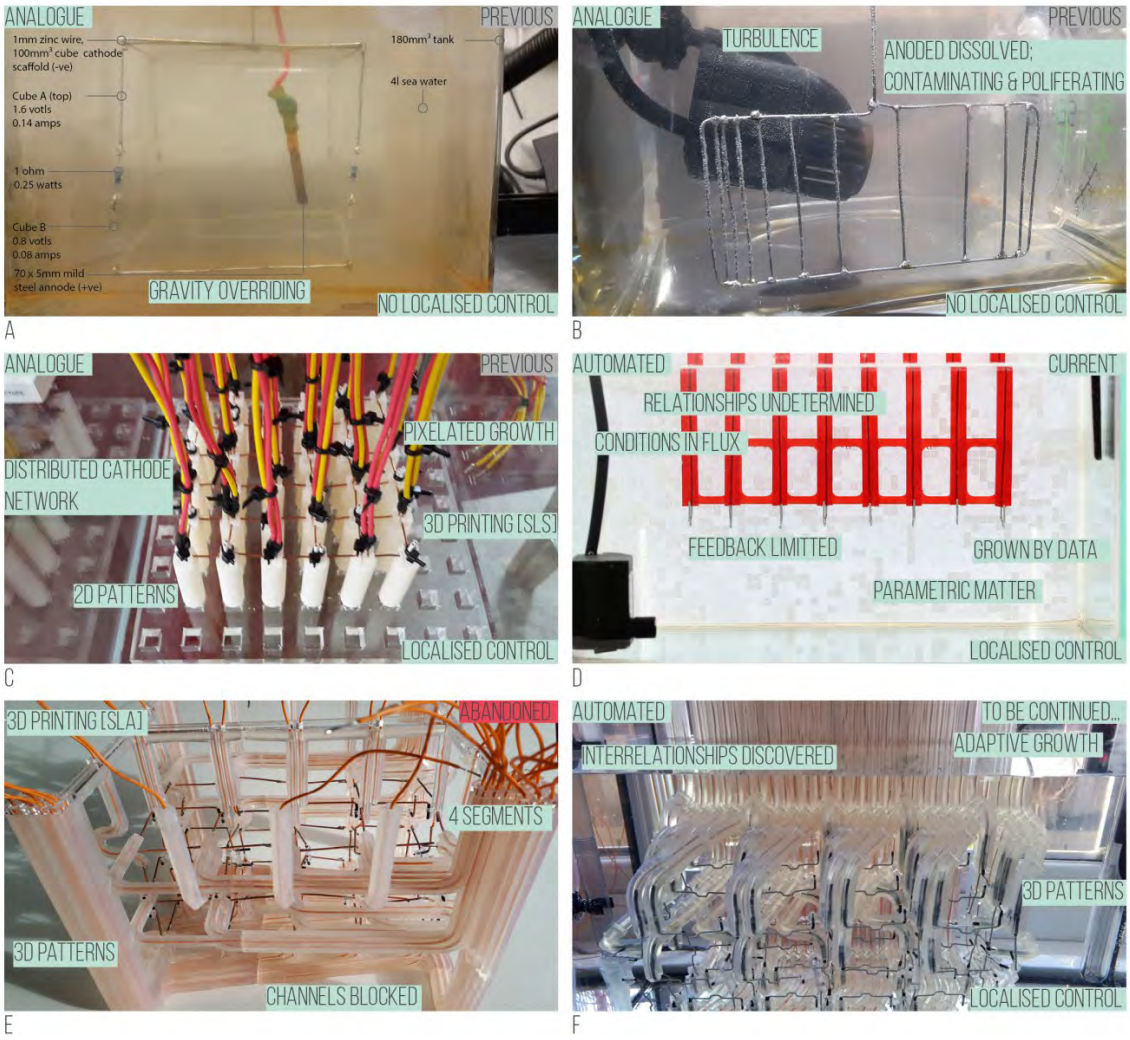


Figure 1. Highlights the sequential (A-F) prototype iterations created to-date. Each photo shows the set-up prior to material growth. The annotations reveal challenges raised by the previous experiment and addressed in the following, which has aided in developing a methodology for growing adaptive physical designs'. Source: Author.

3.1 Experiment 1: Multi-Material Crystal Growth via Mineral Accretion

Typically to design and fabricate physical structures composed of multiple materials a designer digitally defines where the selection of discrete materials are within the design's volume and either assembles the parts, or more often, fabricates it in one piece using layer-by-layer additive manufacturing technologies (C Bader, Kolb, Weaver, & Oxman, 2016; Christoph Bader et al., 2018; Michalatos & Payne, 2013; N Oxman, 2011; N Oxman, Keating, & Tsai, 2011; Richards, Abram , & Rennie, 2017). To challenge this traditional means of fabricating multi-material structures this experiment sought to start with a single superabundant source material, seawater, and explore how different types of materials can be made to self-assemble on a physical scaffold in response to controllable physical stimuli. To do this a metal cathode scaffold was submerged in seawater and subjected to various voltages (Blaney et al., 2015). Lower voltages grow calcium carbonate upon the cathode, whereas higher voltages produce magnesium hydroxide (Goreau, 2012; Hilbertz, 1978, 1979, 1981). *Scanning Electron Microscopy* (SEM) (Figure 2) analysis was used to validate that two material types could be grown.

The key points from this experiment are:

- The fabrication process is able to manufacture different materials from a superabundant source material of seawater, and simultaneously control the placement of that material on a scaffold structure in response to the stimulus of voltage.
- The growth is volumetric and therefore not limited to a layer-by-layer process.

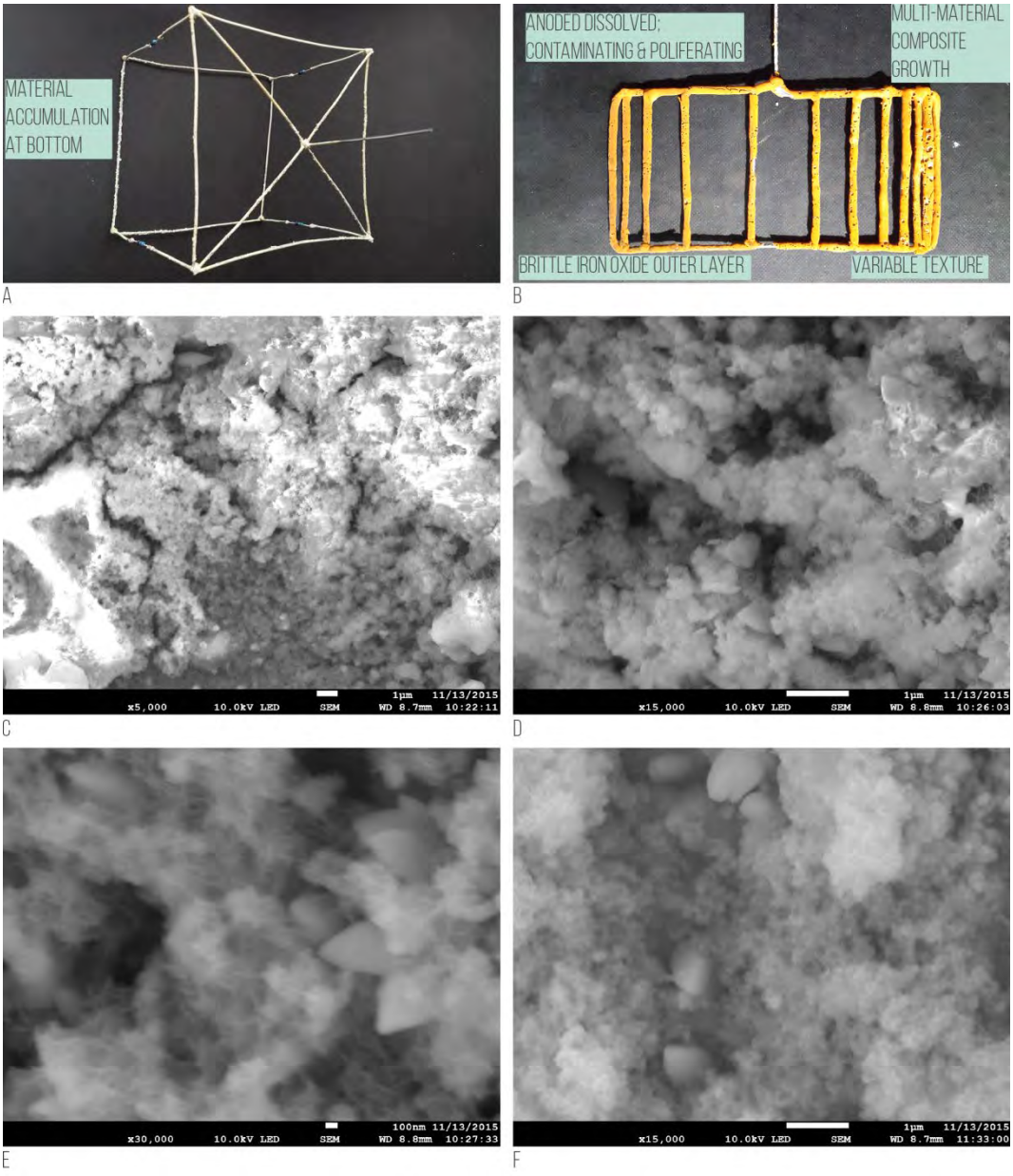


Figure 2. Crystals aggregate over 3D and 2D scaffold simultaneously. A) reveals no localised control over material growth but highlights gravity's effect on aggregation as greater volumes occurred on lower sections. Meaning agitation is required to suspend ions within the solution. B) shows multi-materiality and proliferation in the system as the steel anode dissolved, it coated the cathode, which proliferated throughout the system. C - F) SEM analysis validating multi-materiality; needle shapes reveal calcium carbonate; Dandelion shapes reveal magnesium hydroxide. Source: Author

Limitations of this experiment include: 1) control over localised material location, 2) volume and type due to the all cathodes being connected. Overriding conditions were discovered; chiefly gravity and solution contamination. Gravity resulted in increased volumes of material growing on the lower sections of the cube scaffold, which required turbulence to be introduced into the system to suspend ions and aid uniform growth (Blaney et al., 2015). Solutions contamination was due to the steel anode dissolving, which proliferated and resulted in iron oxide being deposited on the fence cathode.

Offsetting the overriding condition of gravity and proliferation/contamination was achieved by agitating the solution and using a carbon anode. A distributed network of cathodes was created to enable localised control over material properties (volume, location, type) (Figure 3) (see Blaney et al., 2016; Blaney et al., 2017 for full technical details). The scaffold enabled a pixelated heart shape to be grown based on analogue instructions (wires connected, voltages supplied and duration). However, only calcium carbonate or magnesium hydroxide can be grown at any one time as the higher voltage predominates throughout the seawater solution.

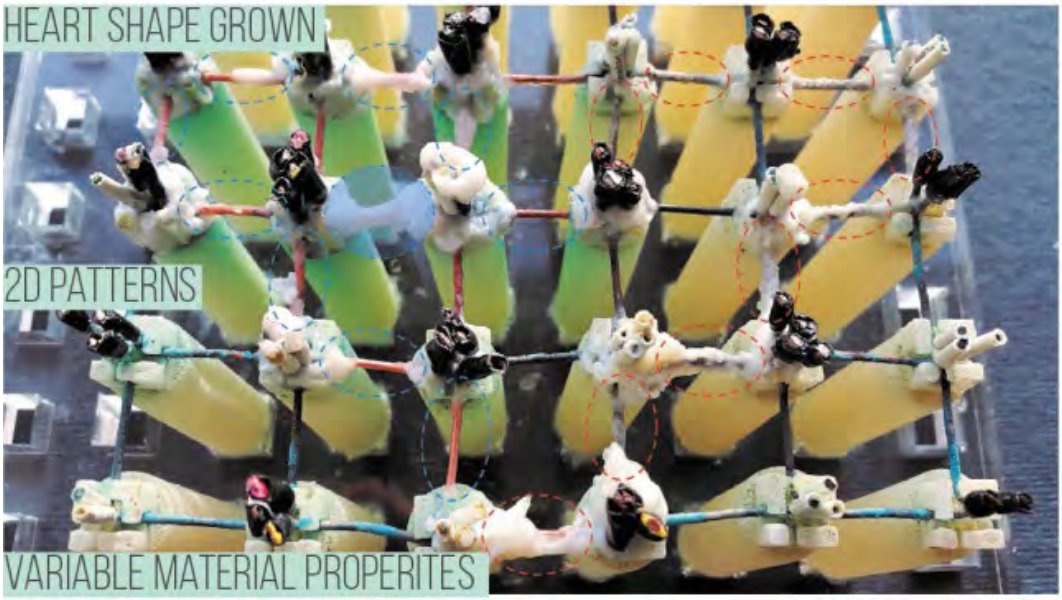


Figure 3. 2D network enabling localised control over material properties (volume, type, location). Source: Author.

3.2 Experiment 2: Growing a Data Visualisation

The first experiment provided a proof-of-principle that material properties and placement can be controlled by 'tuning' environmental stimuli (in this case voltages). However, control of this aggregation had proven difficult. This experiment sought to better understand how designers might control growth. To do this, we first sought to create a physical data visualisation (Jansen et al., 2015) based on the relative size of planets in our solar system. After this, we produced a simple digital interface (created in Processing) to control voltages supplied to cathodes for a second experiment, where the digital interface could control the processes of mineral accretion in real-time (figures 9-10).

Figure 4 documents the physical setup, values and phases of material growth. Significantly, the experiments sought to explore the ease at which the variables of the process (time and voltage) could be governed digitally through the use of hardware (figure 5). The system is an

Open Loop Control System (OLCS) and it highlights issues of control as the growth times were predicted and projected from preliminary experiment results.

The OLCS means that there is no feedback between the design tool that governs the induced stimulus and the resultant material properties and conditions created, as they are not monitored. However, there are multiple conditions that are in flux within this system (salinity, temperature, conductivity, pH, evaporation rates) (Goreau, 2012), which can be monitored via various sensors (Hilbertz, Fletcher, & Krausse, 1977). The benefit of early OLCS is its simplicity. They enable fast prototyping to get to grips with the initial variables of the system and how they can be interacted with.

The ability to offset and maintain these conditions is the next stage of development; creating more hospitable environments to guide material growth. Significantly, a contrasting effect occurs between material volume grown and electrical current. As material volume increases it insulates the cathodes (Goreau, 2012), resulting in a drop in electrical current (Hilbertz et al., 1977). It is this and other interrelationships that are explored in subsequent experiments to establish feedback between design tools and material properties. Determining growth volumes is one aspect of control; the results demonstrate a wide variety of material properties: smooth, porous, tubular, granular, variable densities, thicknesses and internal architectures (Figures 7-10).

The key point here is that by determining how or what conditions and interrelationships produce these results it would be possible to intentionally tune and adapt physical properties of a design manufactured from these material types. For example, imagine a building facade that could increase its insulating abilities as the climate cooled by growing more porous internal architectures. Additionally, if the materials constituting these structures are grown from a sustainable abundant source, like seawater for the mineral accretion process, the urban context could share material resources and behave like an ecosystem, mediating and addressing demands with passive strategies. Another example is medical splints that varied their composition to achieve improved healing to fractured bones and reducing the risk of post-treatment side effects, such as scar tissue accumulation in joints. These abilities could be achieved as the making and designing process is simultaneous and occurs throughout the design’s length and time scales.

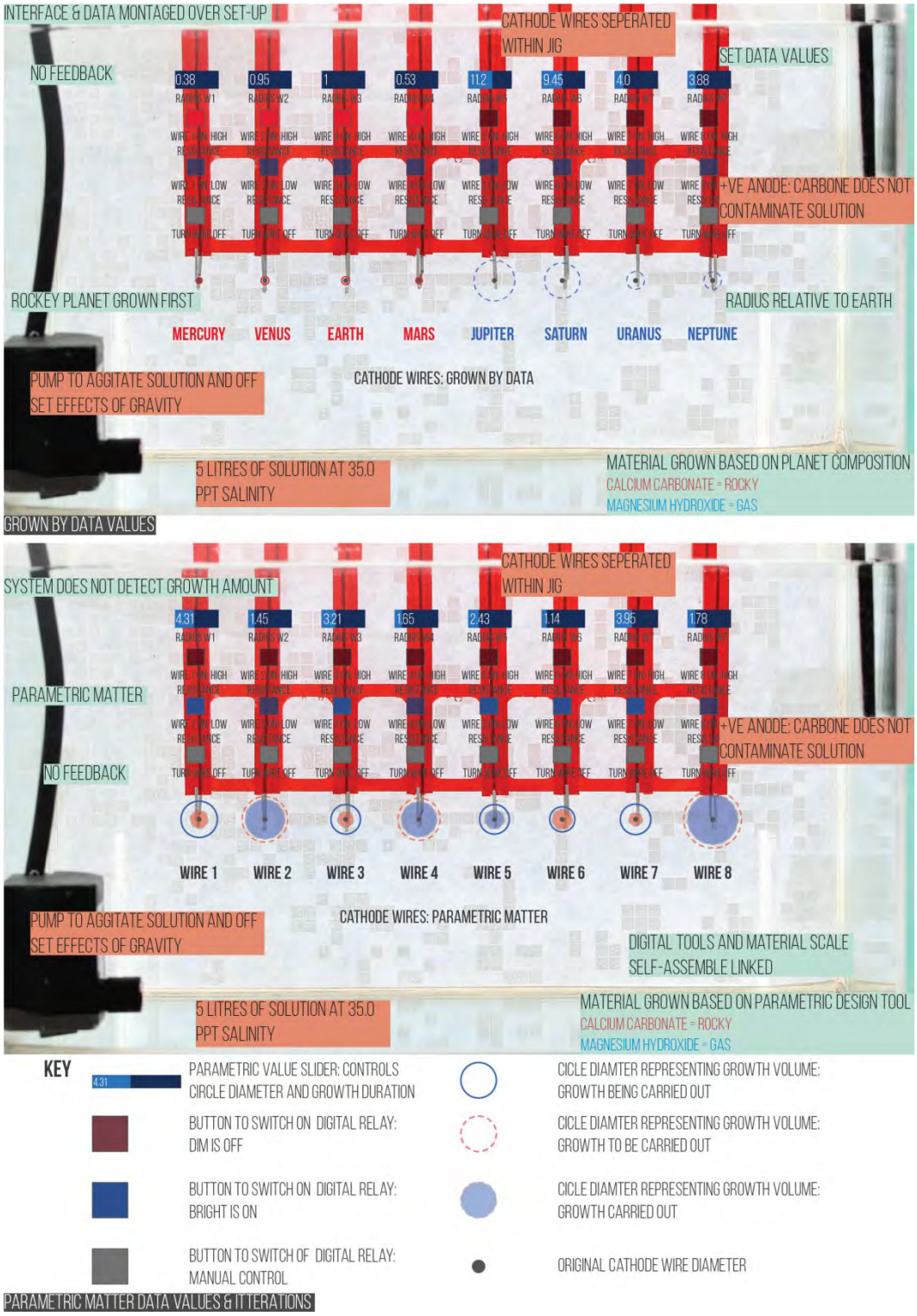


Figure 4. Setup of experiments titled 'grown by data' and 'parametric matter'. Data and interface imposed over physical prototype to convey the connection between design instructions governing material scale self-assembly. By adjusting the digital interface, a designer can impact the growth of the physical structures. Source: Author.

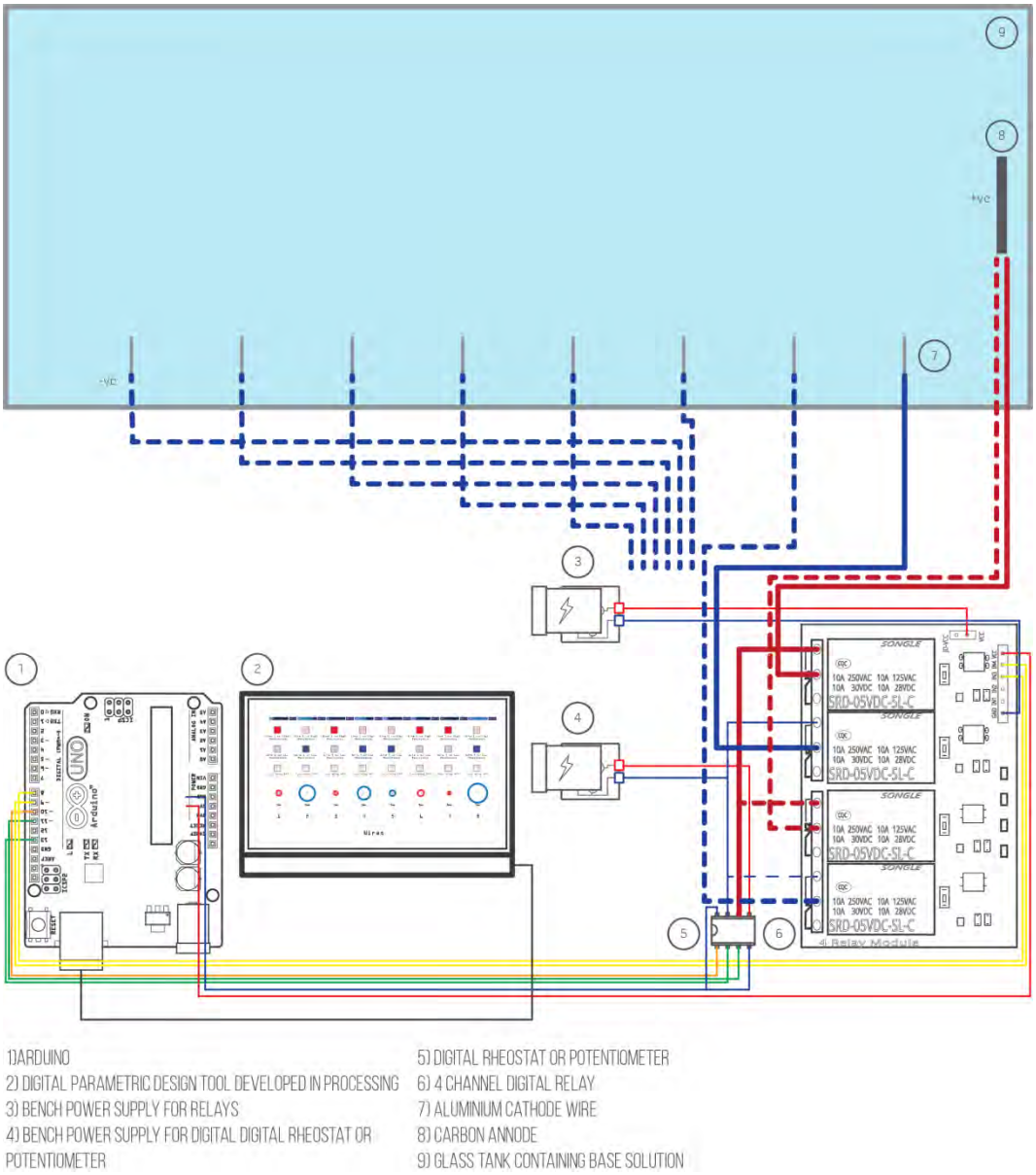


Figure 5. Connection between data and or digital parametric design tool enabled by the hardware platform Arduino and serial communication. Source: Author.

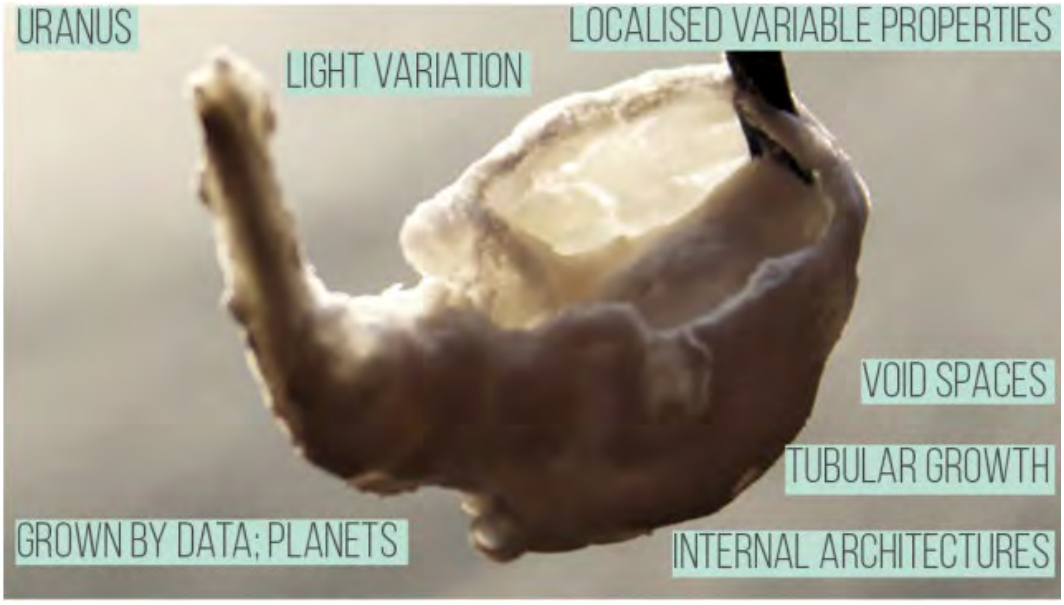


Figure 6. Close up photograph of growth reveals multiple material properties that would be difficult to create using existing digital fabrication processes. Here variable thickness, volumes, textures, densities and internal architectures are all grown. Source: Author.

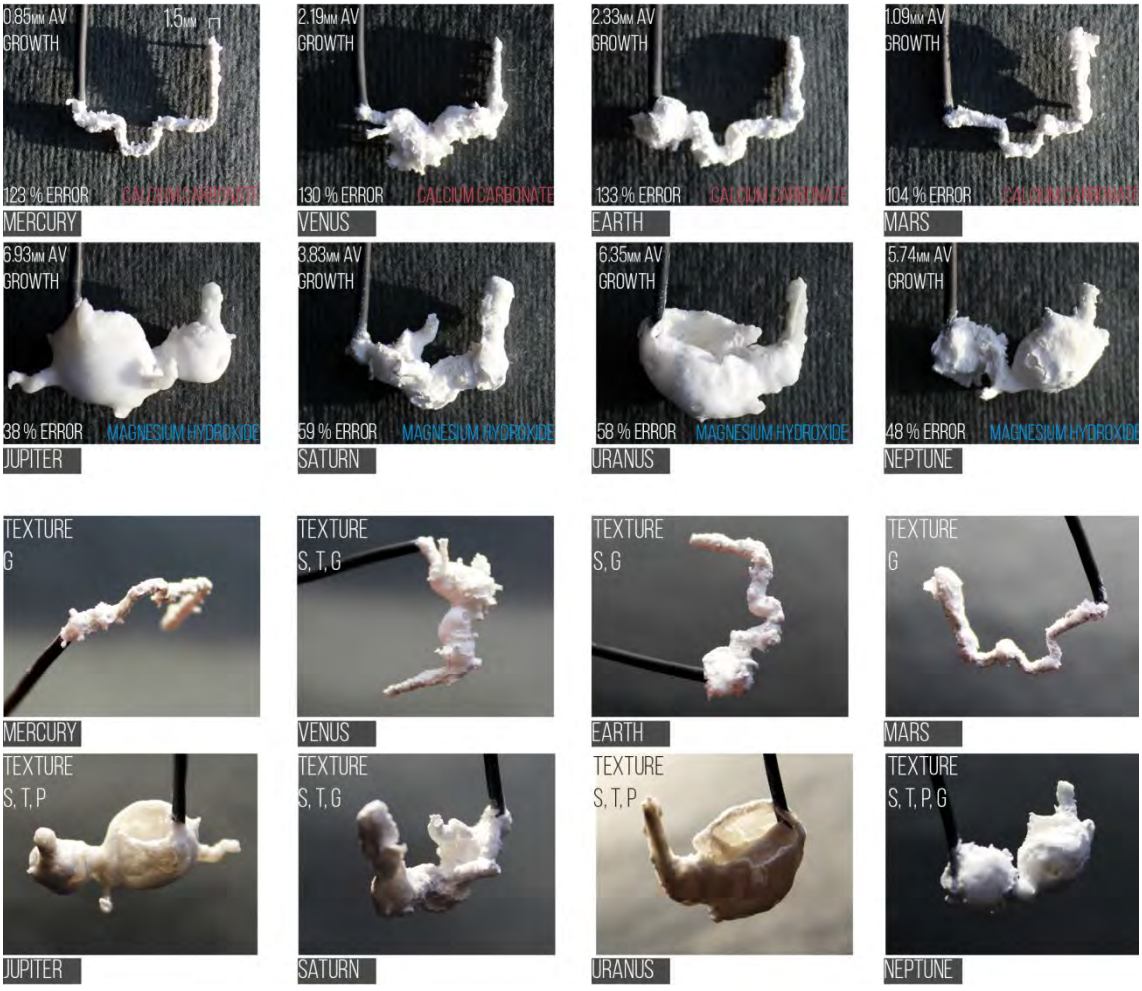


Figure 7. Physical data visualisation. A variety of volumes are grown and more interestingly extremely diverse textures, ranging from smooth to granular as well as volumes that are porous and have internal architectures, particularly evident in the largest material growth volumes of Jupiter and Uranus. Source: Author.

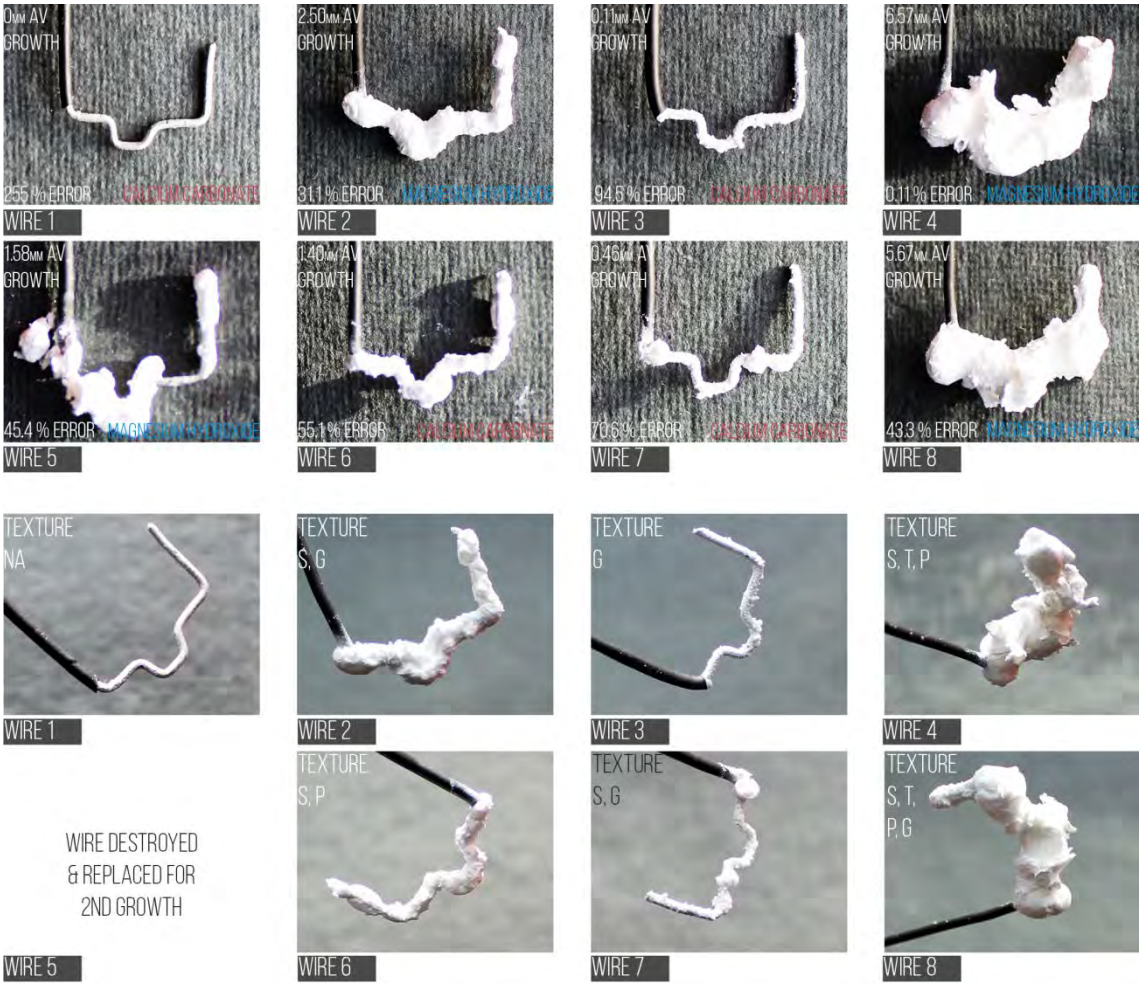


Figure 8. Physical data visualisation growth from the 1st iteration governed by the digital parametric interface. Source: Author.

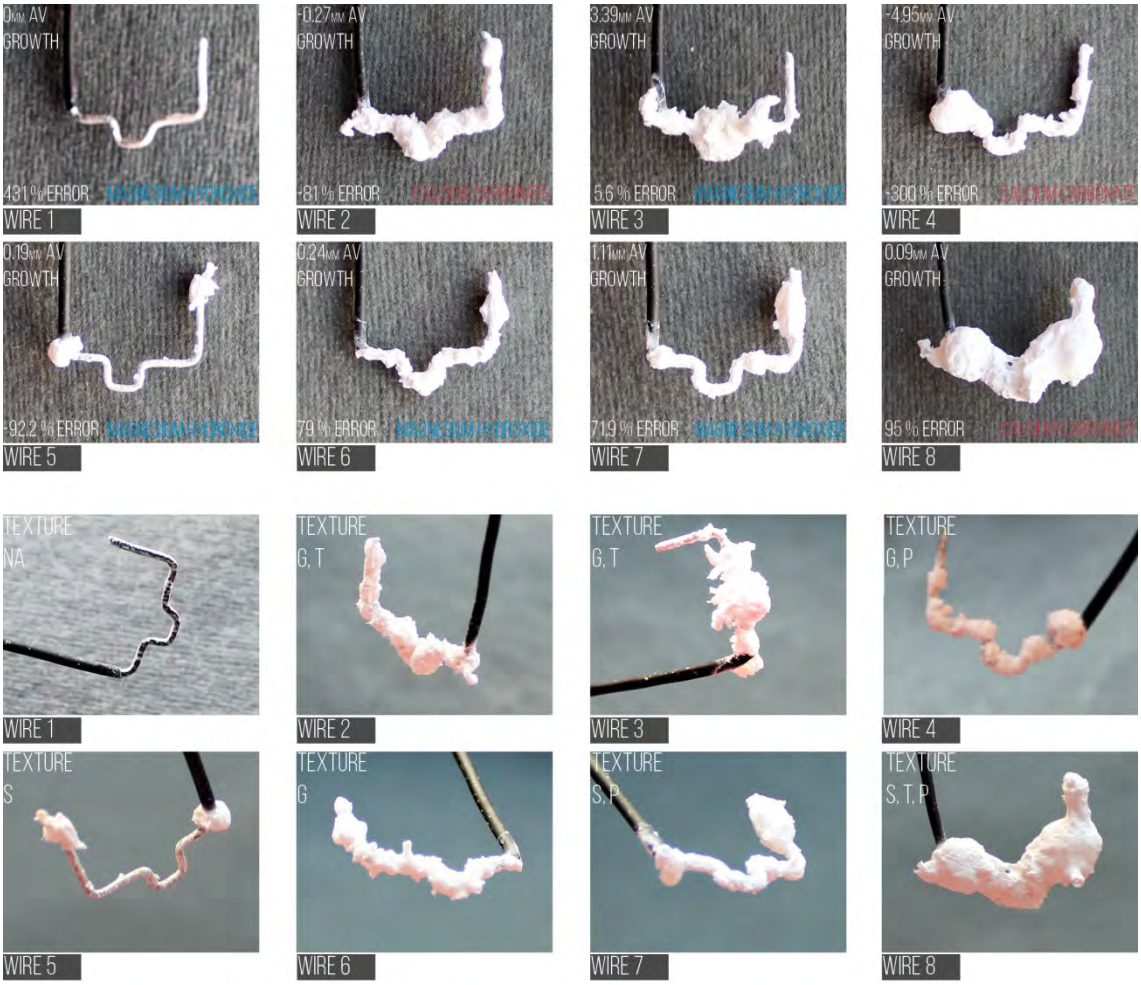


Figure 9. Physical data visualisation growth from the 2nd iteration governed by the digital parametric interface. Source: Author.

3.3 Experiment 3: Growing Pixels and Voxels

The next phase of experiments sought to move beyond the simple scaffold structures by exploring more intricate scaffold structures produced using additive manufacturing technologies. The goal here was to imagine how adaptive materials might be integrated into designs in the near future.

A first attempt (Figure 10) created a complicated 3D scaffold structure from 4 components, but was abandoned as numerous internal channels for feeding through wires became clogged with resin, combined with the tight radii and long length of some of the sections meant numerous connecting wires could not be fed through and attached to their relevant cathode element. A second design addressed this issue by increasing the size of the scaffold's design, which resulted in the internal paths no longer being blocked. This was also facilitated by using multiple shorter sections with larger radii, enabling all of the cathode elements to be connected. However, a trade-off of the multiple-sections approach is that connections between sections lean and distort the overall shape. This is significant as several of the cathode elements sizes do not match the other elements, which could result in anomalous results when comparing electrical current values to determine desired growth properties in those locations. Since this attempt these components of the scaffold have been

re-fabricated and assembled, resulting in uniform cathode elements. A preliminary test of the 3D scaffolds again achieved 3D pixelated crystal aggregation (Figure 11 - 12). During this test, material decay occurred during growth as the bubbles that formed at the cathodes, due to electrolysis, bombarded material growth above them, which resulted in material decay and ultimately failure (Figure 10). A benefit of this could be seen as only robust material growth survives, which acts as a form of error correction and ‘survival of the fittest’ within the turbulent fabrication process. However, this remains for future research that would require interdisciplinary collaboration between designers, electrical engineers, and chemists.

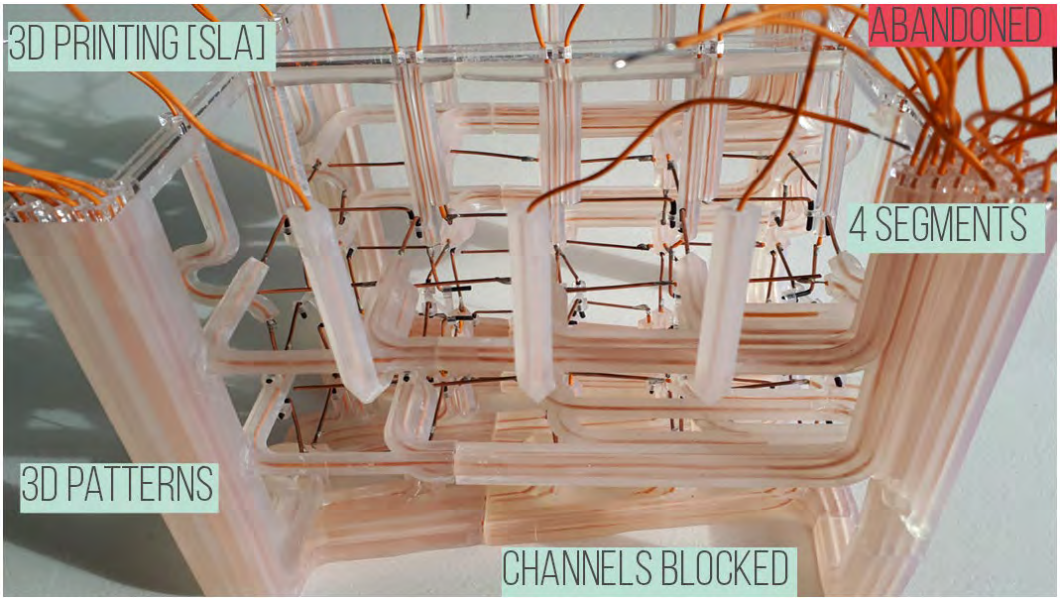


Figure 10. First attempt at 3D printed scaffold abandoned due to blockages within internal channels. Source: Author.

Figure 11. Second attempt at 3D scaffold with preliminary trial growth establishing designs can be grown at a pixelated resolution. Source: Author.

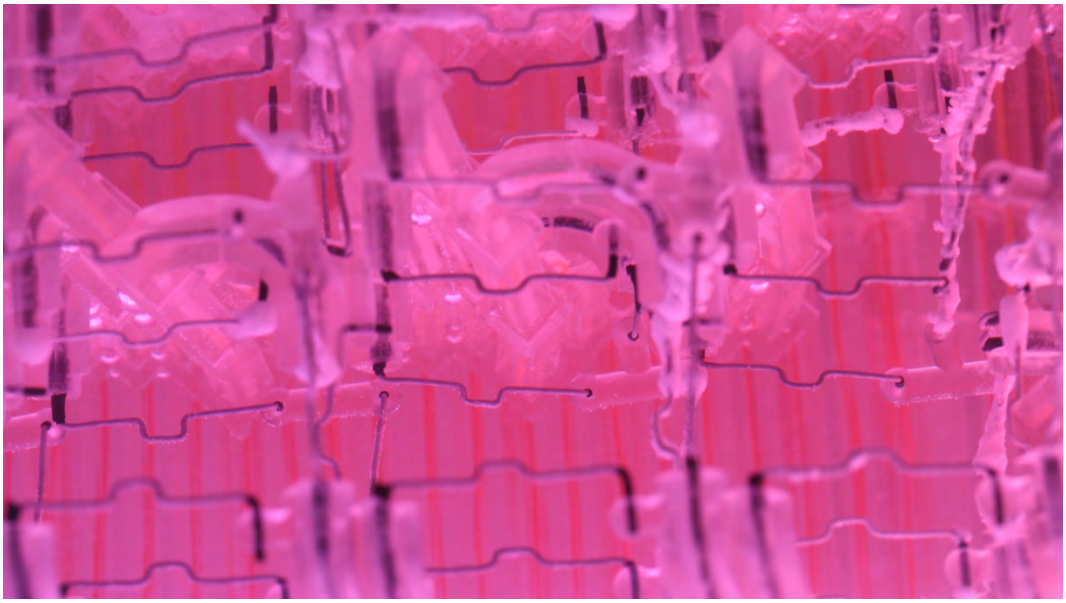


Figure 12. Close up detail of the second 3D scaffold system with preliminary growth testing carried out. Initial growth shows diverse textures again from smooth to branching and tubular textures. Source: Author.

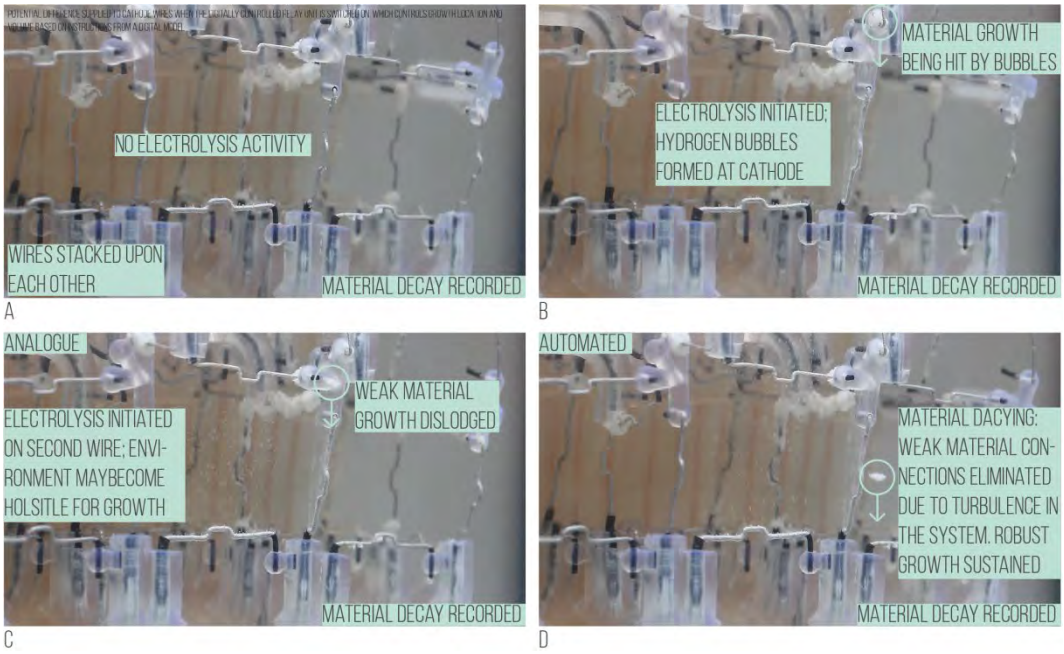


Figure 13. Material decaying from the cathodes due to turbulence induced within the system from electrolysis (hydrogen bubbles). The challenge of detecting this is still to be addressed, but it could be used as a possible error correction mechanism as only robust material growth survives.

3.4 Experiment 4: Using Contrasting Materials as Dynamic Scaffolds

An underlying challenge for these experiments has been the need to grow materials onto a fixed scaffold structure that ultimately defines the shape and form of the final structures. This experiment sought to remove the fixed scaffold, and explore control of viscous paint patterns using contrasting materials that act as dynamic scaffolds.

Significantly, the paint experiments question what constitutes a ‘scaffold medium’ by exploring how various material properties and additives to the paint recipes can effect pattern formations. The sequence of images below (Figures 15 - 19) highlights the various

deposition process, ‘recipes’ and interactions. The key findings highlighted in each titled study are:

- ***Texture:*** Paints were deposited sequentially via a syringe controlled by a stepper motor so deposition rate was constant. The surface texture is uneven (created by crackle paste) and had a significant effect on the mixtures surface tension as it flowed over ridges, which informed streaks, bands and pools of colour.
- ***Location:*** Paints were deposited into a cup using a jig and the syringe system. The cup was flipped on the canvas, which resulted in the interactions taking place in situ. As a result, a diverse range of patterns was produced. As the isopropyl alcohol gradually evaporated the generation of patterns slowed; meaning the system has a form of metabolism, which needs to be replenished in order to keep generating patterns.
- ***Contrast:*** the paint mixture was deposited in one complete extrusion of the syringe system at the centre of the canvas, which meant the interactions between the paint’s colours predominantly occurred within the nozzle of the syringe and resulted in less diverse colour variations. However, this was not the case for the silicone additive as it contrasts with the water-based paint and they do not mix, resulting in void spaces and boundaries by displacing the paint. As such the volume of silicone informed the voids, streaks and variable paint layer patterns and more significantly, it highlights the potential use of contrasting materials as a strategy for guiding self-assembly process that is much more flexible them defined scaffold structures.
- ***3D Contrast:*** Moving into three dimensional volumes, inks were deposited into a volume of two contrasting mediums (oil and water), which form an interface. The inks form contrasting formations within each medium, spherical droplets in oil compared to ink cloud formations in water. The diffusion rates and support medium interface could be developed into a new additive manufacturing processes that create delicate structures volumetrically by tuning environmental conditions, particularity relevant to emerging rapid liquid printing methods (Hajash, Sparrman, Guberan, Laucks, & Tibbits, 2017).

Again there is no feedback between the design tool and process variables in this system but imagine being able to submerge your body parts into a tank, which could grow new types of fashion or medical splints directly onto your body. The location and type of materials grown could be informed and guided by coating your body parts in various contrasting liquids that inhibit and inform growth. Videos and further details on the recipes and deposition process can be found on the link (https://vimeo.com/user12085005).

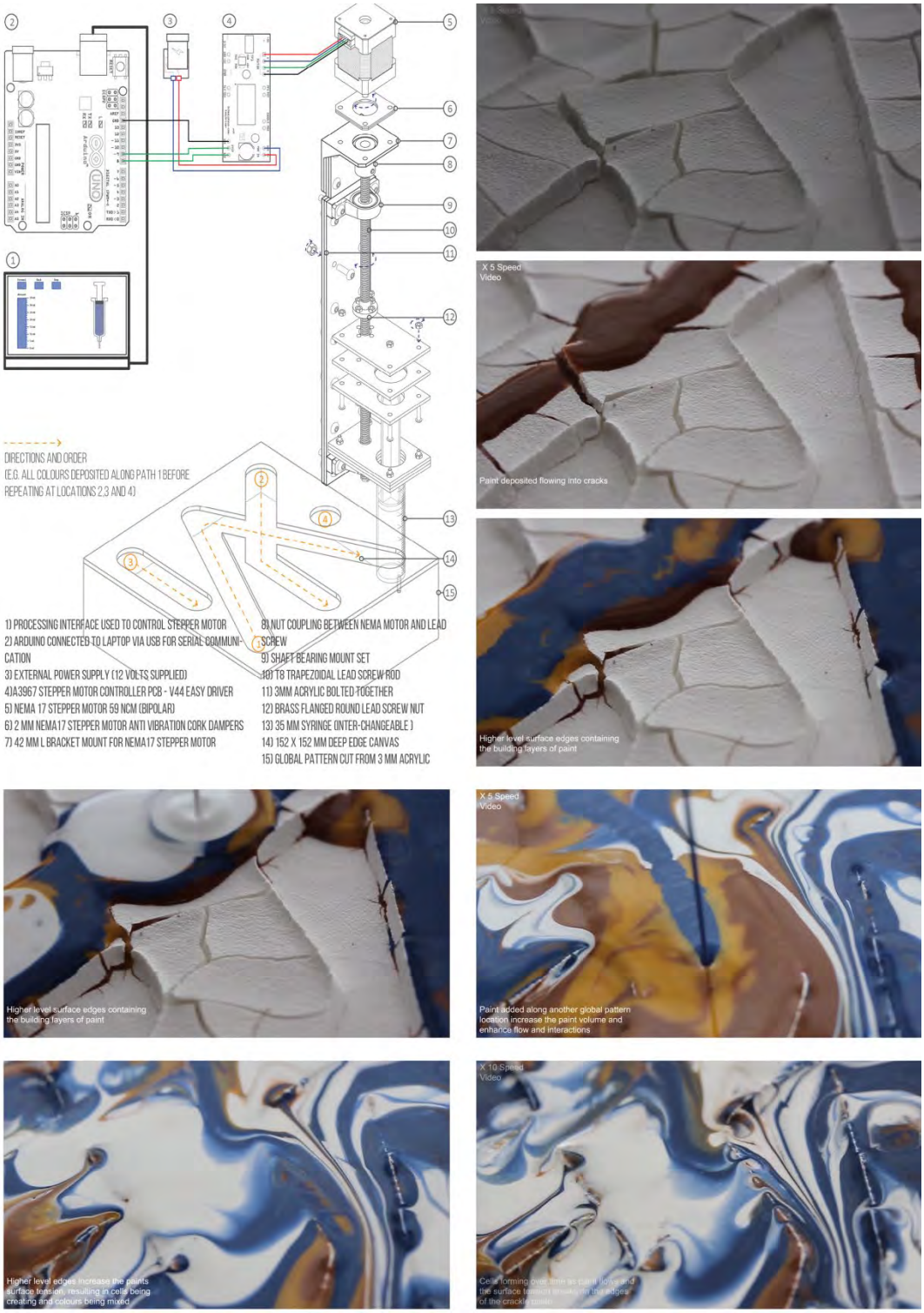


*Figure 14. **Texture**. Series of images revealing how surface texture effects paint interactions and the patterns generated. Source: Author.*

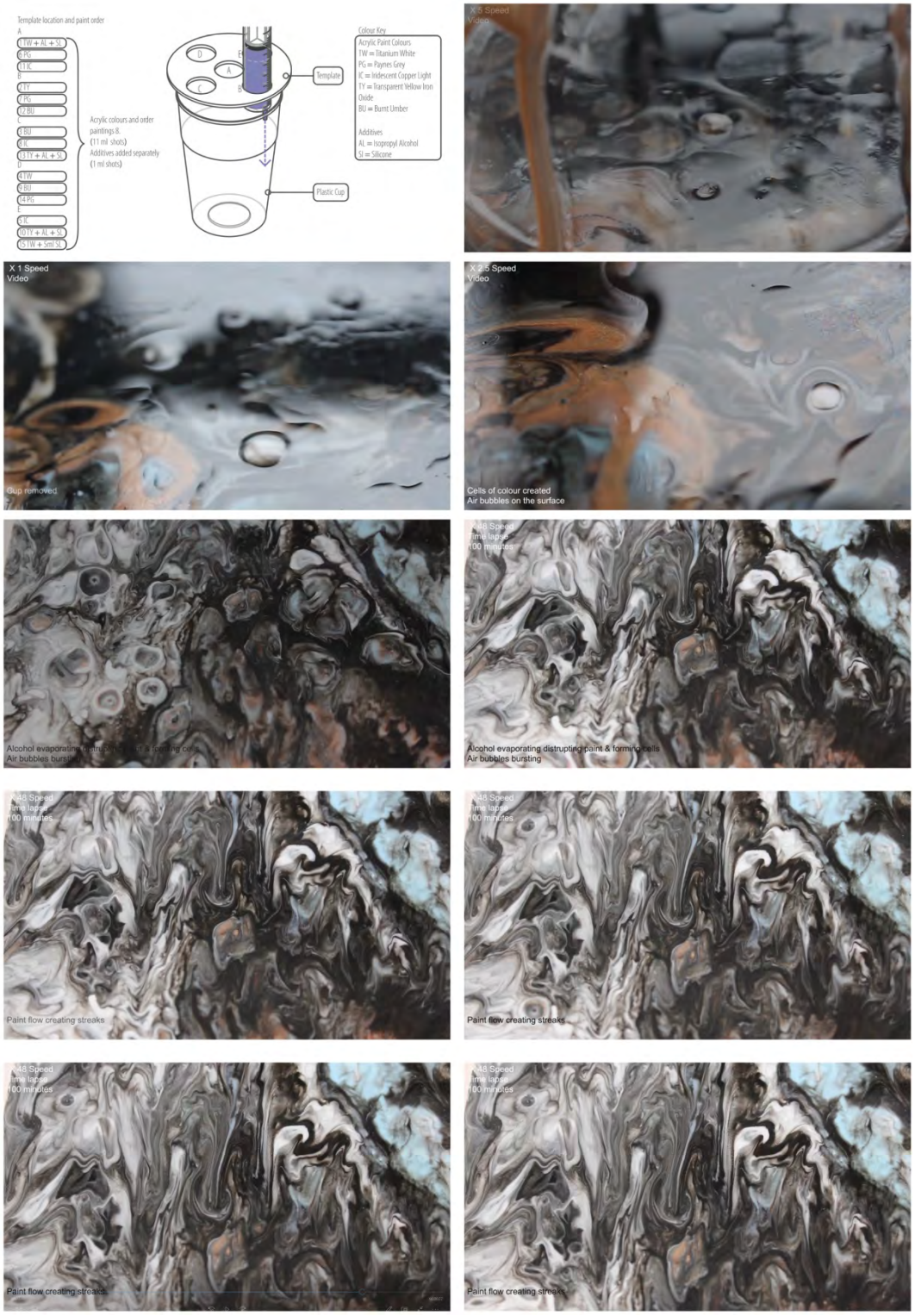


Figure 15. ***Location.*** *Images reveal interactions taking place in situ produces greater pattern diversity. Source: Author.*

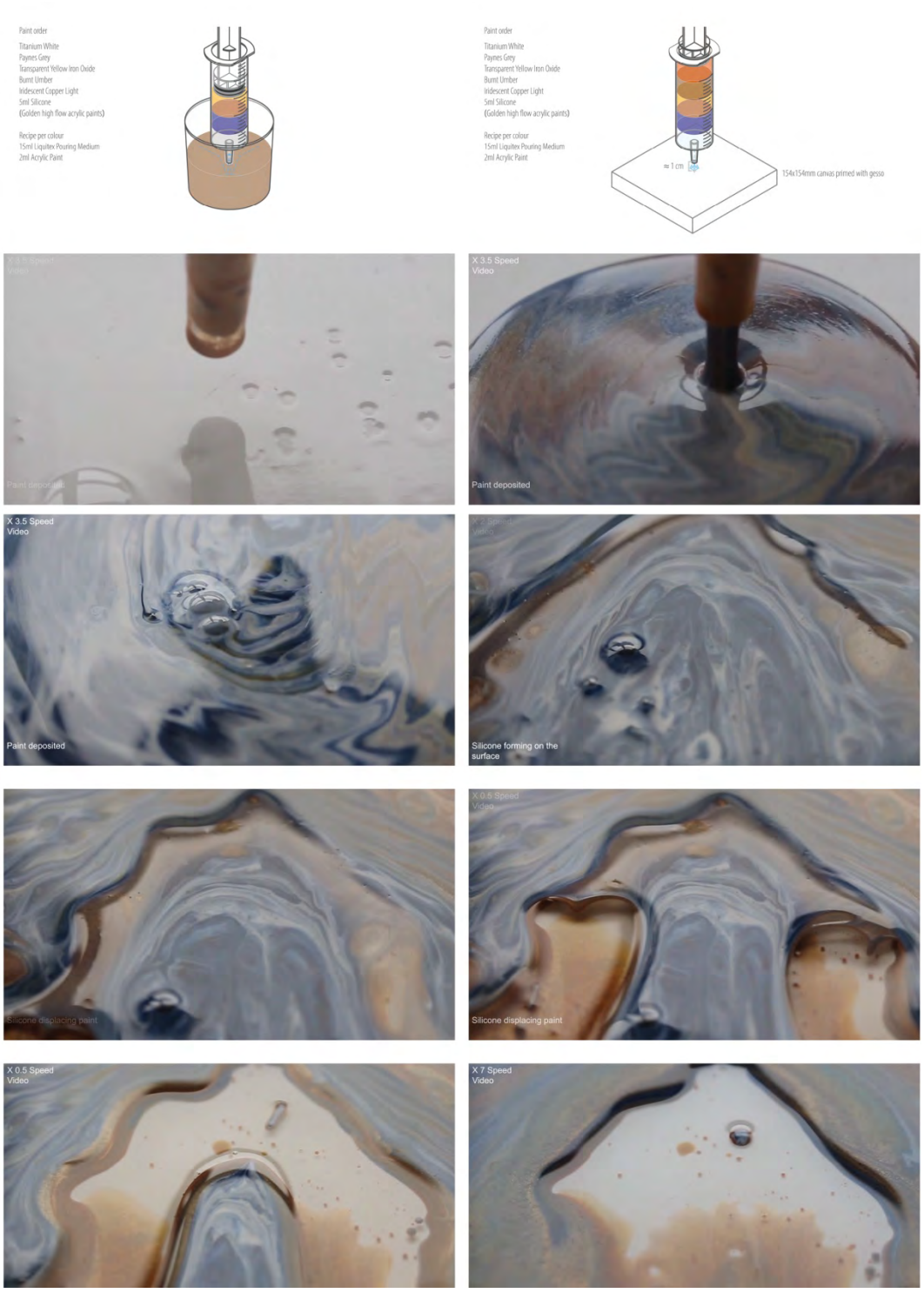


Figure 16. ***Contrast****. Silicone contrasts and displaces acrylic paint informing: voids spaces, boundaries, layers and streak formations, which highlights how contrasting materials can guide self-assembly. Source: Author.*

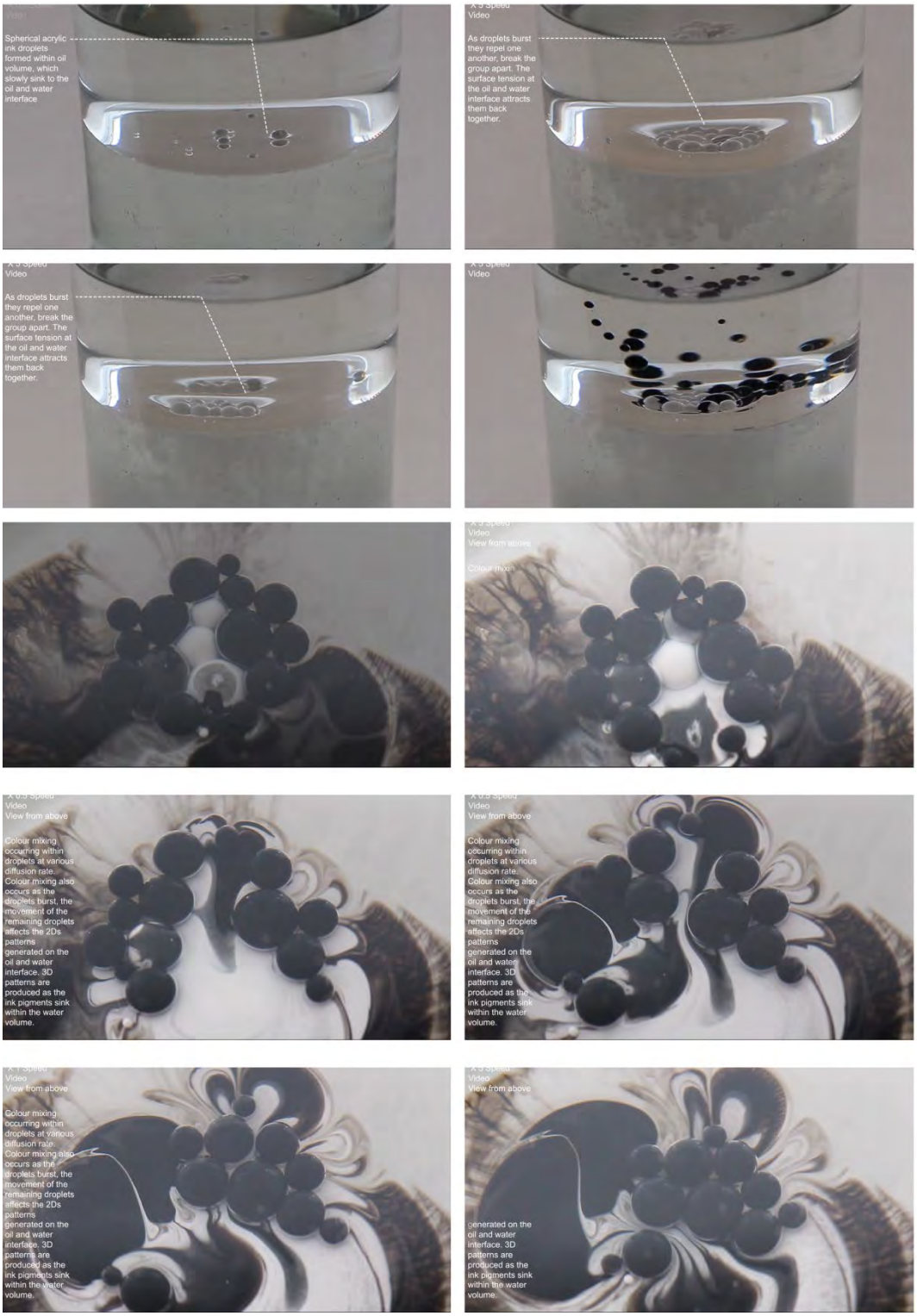
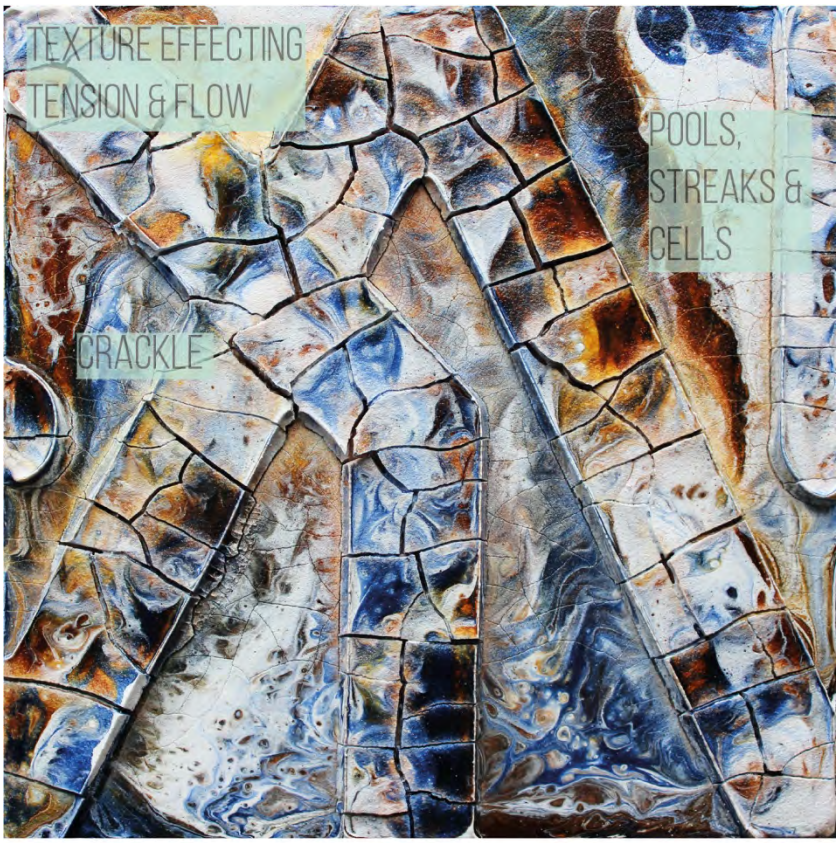
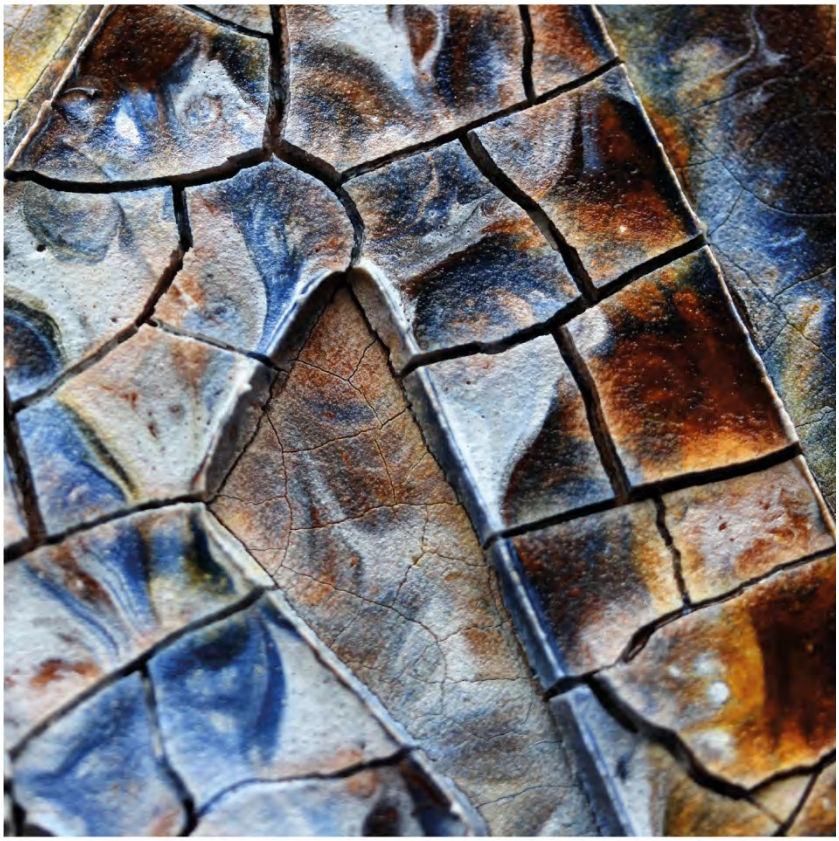


Figure 17. ***3D Contrast****. Reveals ink behaviour within contrasting support volumes; bursting at the oil and water boundary to form ink clouds. Source: Author.*

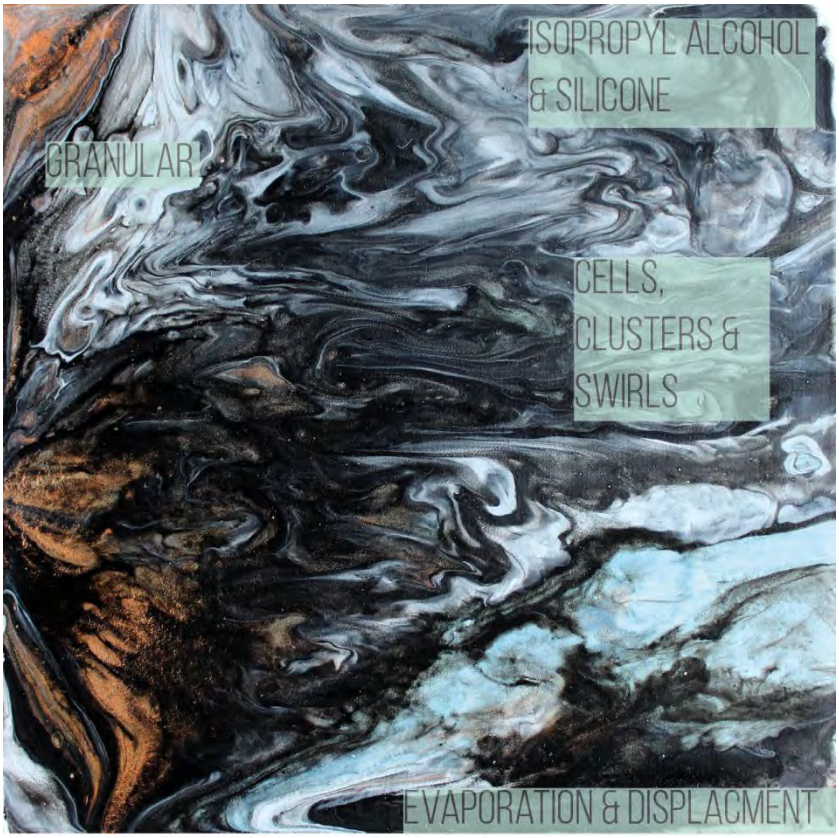


A



B

*Figure 18. Detailed images of **Texture**. Source: Author.*



A

B

*Figure19. Detailed images of **Location**. Source: Author.*

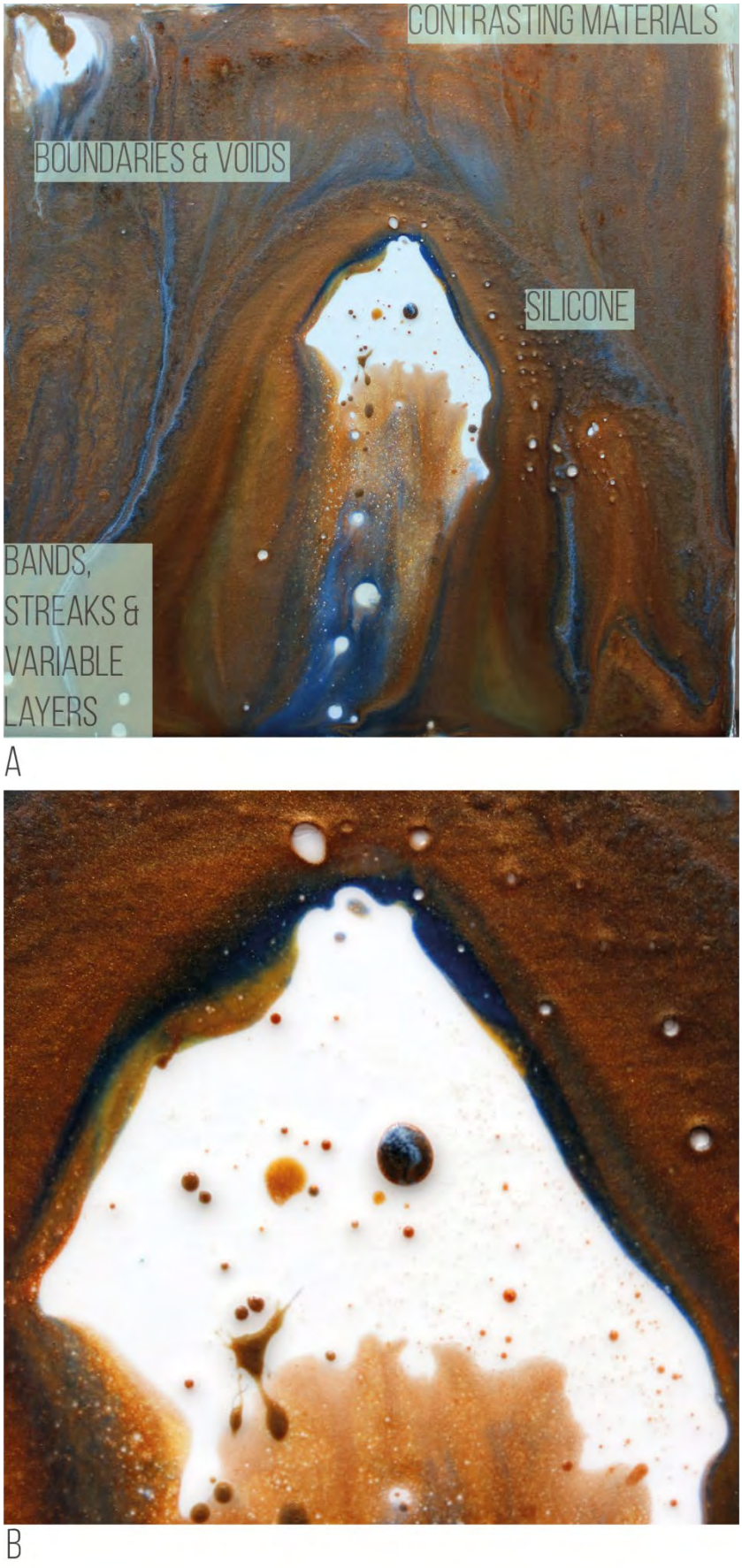


*Figure 20. Detailed images of **Contrast**. Source: Author.*

4 Discussion

This paper has presented a series of design experiments that have sought to explore future design and manufacturing processes based on what we term ‘programmable self-assembly of adaptive materials’. The goal of this paper has been to provoke discussion and instigate further inter-disciplinary collaborations that seek to create new forms of parametric physical matter that possess similar levels of adaptability and flexibility as their digital counterparts. Figure 22 summarises how digital design, fabrication stimulus and self-assembling materials have been used throughout these experiments to offer a framework for further work in this area.

A key component of these experiments has been shifting how design and fabrication processes are controlled – moving from direct control of designs, to control of environmental stimulus that indirectly informs the growth of designs. Throughout this work, we have come to understand that the notion of ‘stimulus’ become multifaceted, nuanced and challenging the more it is interacted with based on the results and highlighted by the annotations of the experiments. We conclude this paper by reflecting on aspects of control, feedback and impact for design.

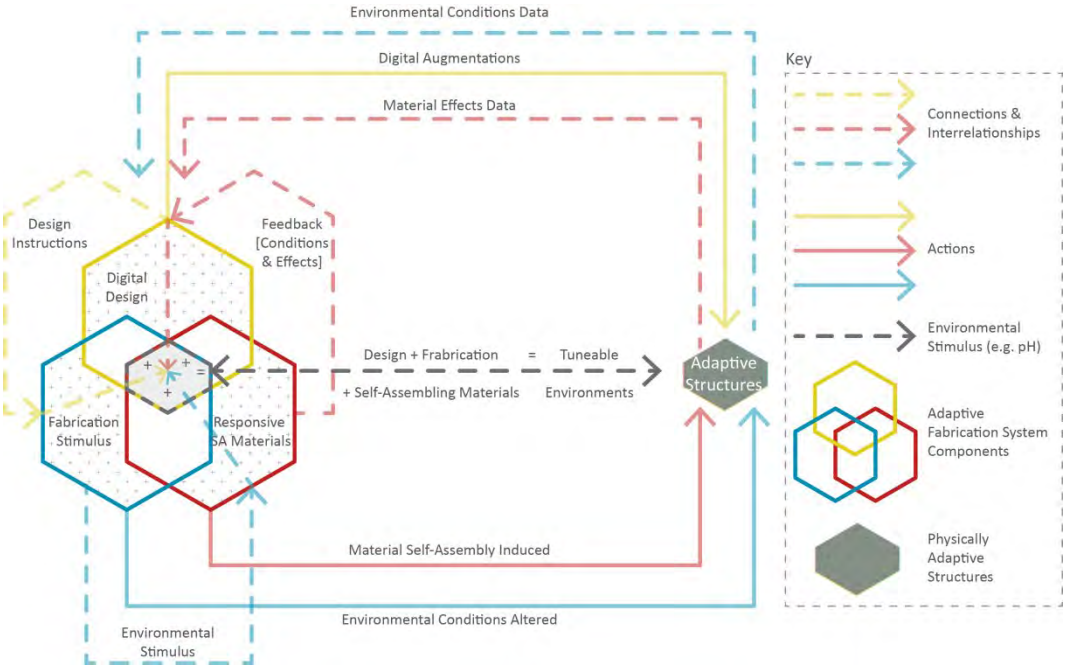


Figure 21. Connections between digital design, fabrication and self-assembling materials enabled via stimulus. Source: Author.

4.1 Reflections on Findings

The series of experiments have highlighted various strategies and design processes for fabricating adaptive structures. Combining the key aspects from the experiments and casting back to the analogue parametric models of Otto and Gaudi highlights two key points of interest when engaging with processes of self-assembly at the material scale by inducing stimulus.

Firstly, this work supports a design and fabrication process that is iterative but also based on interrelationships between stimulus, resultant conditions and the design’s material properties across scales, which opens up a complex and nuanced territory. This is because the fabrication process is non-deterministic and the material properties are not predefined in how

they can be fabricated and through interactions multiple processes and phases could be discovered and evolved to generate designs. Significantly, the process is non-linear as computational material processes are informed and affected by multiple stimuli and inherent properties (DeLanda, 2015), which is challenging but opens up new fertile grounds such as physical adaptation. In order to engage with and understand these complex material interactions and interrelations computational design processes that are not associative are required and highlight a key area for further research.

Secondly, the experiments suggest that the idea of contrast both in resultant conditions and materials could leverage: a) the ability to more accurately guide and determine if desired material properties have been fabricated. Monitoring contrasting conditions between stimulus and resultant material properties, as per the variation in electrical current based on material growth during the mineral accretion process enables feedback between design tools and materials that do not have the capacities to self-sense and fabricate informed designs based on stimulus. b) Contrasting materials point to the potential for developing less restrictive scaffold structures for guiding material scale self-assembly processes, liberating them to become more ornate and achieve more flexible transformations which are not constrained to scaffolds.

4.2 Reflections on Augmented Design Role

As designers, we typically seek to impose form upon materials to craft objects. This work suggests an inversion of this standard operating system, which augments traditional design roles and challenges disciplinary boundaries much like those documents by (Ginsberg, Calvert, Schyfter, Elfick, & Endy, 2014) We hope the experiments outlined in this paper provoke debate about the role we wish to take in shaping future design and manufacturing processes with advanced technologies.

We suggest that the next frontier in digital fabrication may be wet-ware technologies that allow physical designs to heal themselves, respond to change, generate energy, and enable new forms of radically sustainable and vernacular architecture. The first steps towards this vision will require further design experiments that seek to control materials with tuneable environments. Interestingly, this process of making may resemble those of Otto and Gaudi again by engaging with material computational abilities. These sorts of design and fabrication strategies could enable interactions with the complete materiality of objects (local and global properties). Meaning internal architectures and compositions that are based on, and inform, global shape and aesthetic changes, which could lead to: 1) more holistic design solutions, 2) improved material efficiencies and 3) novel design typologies that can be adapted on the fly as the fabrication mechanism is based on stimuli and caters for time.

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Fostering creative citizens in China through co-design and public makerspaces

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This paper presents preliminary findings of a research project aims to propose a novel combination of 1) design interventions, 2) public makerspaces and 3) online design resources as a means of fostering creative citizens in China in an inclusive and bottom-up manner. The preliminary findings comprise research results from the literature review and case studies investigating current practices of makerspaces and similar creative spaces including hackerspaces and fab labs. It was observed that existing studies appeared to focus on facilities and benefits that makerspaces offer to users and/or communities. While there was a certain amount of research that investigated relationships between makerspaces and makers, the notion of empowerment was rarely explored. To complement previous studies, this research will focus on how makerspaces could 1) empower people to make and 2) empower people through making. The case studies – one in the UK and one from China – reveal that having a clear target audience and suitable measures to support them is the key. The social aspects (e.g. providing a dedicated social space for people to socialise, share ideas and learn from each other) are as important if not more so than practical matters, e.g. offering mentoring programmes. Informal settings appear to work well with people with less making experience, as it encourages socialisation, idea exchange and casual conversations. Rather than seeing makerspaces as a place to make artefacts, both cases perceived themselves as a *'platform'* for *'making people'*, e.g. equipping them with skills which will help them pursue their goals.

Keywords: Maker, Makerspace, Co-design, Creativity, Community

1 Introduction

This paper aims to discuss the preliminary results of the research project titled *"Fostering Creative Citizens through Co-Design and Public Makerspaces"* funded by the Arts and Humanities Research Council, UK. The study seeks to develop a novel and inclusive means of fostering creative citizens in China in a bottom-up manner through the strategic use of co-design and public makerspaces. The project is a collaboration of academics from Brunel University London, UK and Tongji University, China, and practitioners in the creative sector, namely The Glass-House Community-led Design, Engine Service Design and Tangerine.

The rationale is that human capital has increasingly become the most important asset of a country, and the key to the sustainable economic growth of a city/country is an ability to attract, nurture and retain creative workforce (Florida, 2002). This argument matches the

prediction of the World Economic Forum (2016), which suggests that in 2020, the top skills that employers will be looking for are complex problem-solving, critical thinking and creativity respectively. Previous studies showed that people outside creative disciplines also make design decisions (e.g. brand identity and product ideas) without realising it (Kotler and Rath, 1984). By introducing creative thinking to the Chinese workforce, they will be better equipped to make design decisions, which could lead to better business performance. This project will go beyond supporting people in paid employment and include as many people as possible regardless of their demographic groups, since people outside paid employment could also contribute positively to sustainable economic developments, e.g. carrying out voluntary work.

One effective way of promoting and fostering creativity is to actively engage people in creative activities, such as co-design (Sanders and Stappers, 2008). Previous studies showed that engaging people in the co-design process not only helps fostering participants' creativity, but could also lead to many social benefits, such as encourage self-help attitudes (Boyle and Harris, 2009). As a result, this project intends to foster creative citizens through a novel combination of 1) design interventions, 2) public makerspaces and 3) online design resources. The design interventions will be delivered through co-design projects between designers and community members. The public makerspaces, in this case, refer to physical locations where people gather to co-create, share resources and knowledge, work on projects, network, and build (Department for Digital, Culture, Media and Sport, 2017). The emphasis is on offering multipurpose spaces where creative activities can take place, rather than provide high-tech fabrication tools. In this case, online design resources will be provided in a form of the design case study bank, which will act as a digital repository of community-generated solutions which could be used as building blocks for future developments. This paper will discuss the key findings from two research activities in the first year: literature review and case studies, which seek insights from the best practices of creative communities and makerspaces in the UK and other countries.

2 Literature Review

The overall structure of the literature review aims to cover three key areas (namely makerspaces and similar establishments, co-design and creative citizens) and their interrelationships. However, the literature review in this paper will focus on developing an in-depth understanding of the current situations of existing makerspaces. This knowledge will provide a useful foundation for future investigations, which intend to identify potential roles of makerspaces in fostering creative citizens.

2.1 What is a makerspace?

The *'makerspace'* phenomenon has been widely studied by various disciplines from many different countries, such as the US, the UK, Australia, Scandinavians and China. Sleigh, Stewart and Stokes (2015) described a makerspace as *"an open workshop with different tools and equipment, where people can go independently to make something"*. Halverson and Sheridan (2014; cited in Litts, 2015) gave a broader definition of makerspaces as *"communities of practice constructed in a physical place set aside for a group of people to use as a core part of their practice"*. While makerspaces are similar to hackerspaces and fab labs in a sense that they are community workshops where members share tools, ideas and knowledge for professional gain or hobbyist pursuits, they are governed by different beliefs (van Holm 2014). For example, hackerspaces reflect the hacking ethos, which believes that *"essential lessons can be learned about the system from taking things apart, seeing how*

they work, and using this knowledge to create new and more interesting things" (Levy, 2010; cited in van Holm 2014). Due to its origin, hackerspaces are more focused on computers and electronics. Fab labs have well-defined characteristics, since the Massachusetts Institutes of Technology or MIT that originated the concept provide clear guidelines for setting up a fab lab. Any organisation that wants to use the term fab lab must adhere to its main qualities, such as public access, support and subscribe to the fab lab charter and participation in the network of fab labs.

Wang, Dunn and Coulton (2015) placed emphasis on community and experience of makerspaces, and, hence, defined the term as *"an experience-led community space where people gather to make things together with the assistance of both digital and traditional making tools"*. The authors argued that makerspaces are designed to stimulate both social and technological innovation. They also explored the differences between two possible models of makerspaces – 1) the community space; and 2) a space for communities. They described the former as *"a space that serves a specific community group"*. In this case, the specific community refer to the members of makerspaces, which make this space rather exclusive – especially, some memberships require a formal registration/subscription with a payment. The latter was defined as a place to open to multiple communities that can be seen as a temporary community of makers. The latter model emphasised on inclusivity (see Table 1).

Table 1 Difference between Two Community Space Models

	Community Space	**Space for Communities**
Community group	One specific community	Multiple communities
Easy to access	Not necessary	A Must
Funding resources	Mostly membership	Other resources

Source: Wang, Dunn and Coulton (2015)

2.2 Why is it important?

Smith (2015) noted that makerspaces, fab labs, and hackerspaces are *"part of global movement of community-based digital fabrication workshops"*. Sleigh, Stewart and Stokes (2015) described makerspaces as *"potential game changers for design, entrepreneurship, fabrication, manufacturing and technological innovation"*. This might be because the act of making has strong connections with technological innovation, especially the democratization of innovation (Toombs, Bardzell and Bardzell, 2014). As a result, a large amount of investments have been made to support the development of makerspaces – for example, Northern Ireland's Department for Culture, Arts and Leisure invested £350,000 into existing makerspaces in 2014 and the UK' Department of Business, Innovation and Skills (BIS) has announced plans to create a makerspace in disused military workshops (Sleigh, Stewart and Stokes, 2015). Currently, there are approximately 440 fab labs in 33 countries (Smith, 2015).

Many recent studies also explored the potential role of makerspaces in supporting education, especially STEM (Science, Technology, Engineering and Mathematics) subjects. Several researchers perceive *'making'* as effective means to educate students about complex problem solving and build future engineering capacity (see Lande and Jordan, 2014; and Kjällander et al, 2017 for examples). In his *'Educate to Innovate'* campaign, the former US president Barack Obama (2009) committed over $260 million to provide a hands-on approach to STEM subjects. The value making experience was clearly highlighted in this plan.

2.3 Who uses makerspaces?

Users of makerspaces are generally referred to as 'makers'. Lande and Jordan (2014) defined makers as *"a group of do-it-yourself minded individuals participating in formal and informal communities (doing-it-together and doing-it-with-others) that support and celebrate building and prototyping technical proof-of-concept exploration and ad hoc product development."* Van Holm (2014) gave a broader definition, which described a maker as *"individuals or groups producing objects as part of a do-it-yourself culture."* The author elaborated that a maker can be *"an individual building a 3D printer from an online guide, but can also be someone cooking a family meal or a computer scientist creating a new web service"*. Generally, makers are broadly defined than hackers. Toombs, Bardzell and Bardzell (2014) suggested that maker identity is informed by three primary factors, namely: 1) the development of a tool and material sensitivity; 2) the cultivation of an adhocist attitude as an approach to making in general; and 3) engagement with the maker community. The first factor refers to an understanding of how to use and select appropriate tools as well as materials/medium for a making job. The second factor suggests that makers are generally motivated by practicality and have a high level of optimism and confidence. The last factor refers to their interests in engaging/being part of a community of makers.

According to the study conducted by Sleigh, Stewart and Stokes (2015), 80% of makerspace users in the UK are men. This finding is similar to the global statistical data gathered by Moilanen (2012). His study in 2010 showed that the typical member of hackspaces was a 26-29 years old male (94%) with college level or higher education (ibid). Similarly, the results of his study in 2011 suggested that the typical member of hackspaces was a 27-31 years old male (90%) with college level or higher education. The small survey conducted by Lande and Jordan (2014) with 37 participants at Mesa maker event in Arizona revealed that 57% of makers described themselves as artist, followed by designer (49%), crafter (49%), hobbyist (38%) and builder (38%). These findings are similar to the results from Belbin and Newcombe (2013 cited in Slatter and Howard 2013), which reported that the average makerspace users described themselves as *"inventors, artists, entrepreneurs, crafters and youth groups"*. As a result, several experts expressed concerns that a large proportion of makers are affluent males with technical or creative backgrounds.

Toombs, Bardzell, and Bardzell (2015) pointed out that the ethos that *'anyone can be a maker'* could obstruct the fact that *'not everyone can be a maker'*. The authors observed that people from certain demographic groups (e.g. a single mum with part-time jobs without a car) might find it harder to engage with a community of maker and makerspaces. To make disengaged groups, such as young women, interested in making, many makerspaces organised specific events, e.g. MakerGirl which targeted girls aged 9 – 15 and MakeHer which welcome adult women only (Kjällander et al, 2017). The overall goal was to create a learning space and a setting where women feel more comfortable, as well as creating role models for girls. Several researchers pointed out that makerspaces should also be designed to accommodate people with special requirements as well. For instance, Hurst and Kane (2013) argued that technologies available in makerspaces could enable people with disabilities to create, modify or build their own assistive devices, which could make assistive technology more accessible to a wider audience. According to Sleigh, Stewart and Stokes (2015), 82% of UK makerspaces have wheelchair access. Although there are makerspaces in every region in the UK, Taylor, Hurley and Connolly (2016) observed that the makerspace facilities are unevenly spread – London, the North West, the South East and Scotland have

more than ten makerspaces each, while the East Midlands, Northern Ireland and the North East each have less than five (Sleigh, Stewart and Stokes, 2015).

2.4 What motivates makers to make?

A larger survey conducted with 2,600 participants, who were members of DIY communities, revealed that their main motivations for contributing to DIY projects were to *"express myself/be creative"* (Kuznetsov and Paulos, 2010). According to van Holm (2014), the majority of items produced in makerspaces will not go to market, and even fewer will be considered commercially successful. Hence, it can be observed that makers are not motivated by commercial gains. According to Moilanen (2012), although the main purpose of visiting makerspaces was still *'building objects'*, *'social aspects'* was selected as the second most important reason. The results of his worldwide survey in 2011 revealed that 69% participated for fun; 34% wanted to help people without getting something in return, and 34% participated due to their commitment to the community (ibid). In addition, Sleigh, Stewart and Stokes (2015) stated that the top three reasons people use makerspace were socialising (41%), learning (35%) and making (33%). Kuznetsov and Paulos, (2010) found out that the majority of DIY projects cost less than $50. The relatively low financial threshold allows a variety of user group to work with a range of materials across different project domains.

2.5 What role does Makerspace play in a community context?

The research titled *'In the Making Project'* funded by AHRC identified the wider roles that makerspaces play in public life in four broad themes: 1) acting as social spaces; 2) supporting wellbeing; 3) serving the needs of the communities they are located in; and 4) reaching out to excluded groups (Taylor, Hurley and Connolly, 2016). The researchers argued that makerspaces could be seen as the third place, which they defined as *"public resources dedicated to creativity, learning and openness"*. According to their study, makerspaces could act as social spaces by providing a hub where people could work together, learn from each other and socialise. It could serve the needs of the communities by carrying out small making jobs for local residents, schools or local governments without undermining local businesses. Makerspaces could support wellbeing by providing creative endeavours which have positive effects on physical and mental health. Lastly, it could reach out to disengaged groups through various events and workshops.

Other studies also highlighted the importance of social aspects. For example, Moilanen (2012) reported that hackers perceived hackerspaces as their *'home'*. Moreover, the study of Slatter and Howard (2013), which investigated makerspaces in Australian public libraries, strongly emphasised on the need for engaging with the community. The interviewees in their study emphasised the importance of partnership, awareness and advocacy from the local community in order to create a successful makerspace. They also stressed the importance of an existing DIY and/or hacker culture in the community – see one of their quotes for an example: *"If you had a community who can't swim and don't want to learn how to swim, and then you suddenly build a huge aquatic centre in the middle, it's not going to be successful."*

Paonessa and Orozco (n.d.) argued that makerspaces could be used to promote community development. Firstly, makerspaces offer physical spaces which enable people to share tools and other resources, network with each other and exchange ideas. The authors observed that this kind of openness could lead to open innovation with social impact. They used Mess Hall, a makerspace in Washington DC, as an example of social innovation. This makerspace promotes local food production which has helped address the issue of food security in the

local area. Mess Hall contains 35 food businesses which not only share physical space, but also ingredients, experience and knowledge. Secondly, they suggested that by providing tools to materialise ideas, makerspaces could help address the phenomenon called *'idea gap'* where people give up on their ideas because they have no means to realise them. Besides, makerspaces could support local startups by offering physical spaces and appropriate tools. A similar idea was explored by Smith (2015), who argued that makerspaces could support grassroots activism. He gave an example of the city of Barcelona where a fab lab was perceived as means to equip maker-citizens with useful tools and open source designs that enable them to play a more active role in city development.

It can be seen that makerspaces have attracted interests of a wide range of audiences and have been strategically utilised to support several positive actions and grassroots movements, e.g. STEM education, social innovation and community developments. However, studies exploring how makerspaces could be used to foster creative citizen are still rare. These initial findings have provided a direction for primary studies, which will focus on **relationships** between makerspaces and makers, especially how they **empower** users.

3 Case Studies

The case study approach was chosen for the preliminary stage of the project since it enables the researchers to develop an in-depth understanding of the chosen subjects within a short period of time (Bell, 1999). PACT Analysis (which is short for People; Activities, Context and Technologies) was chosen to provide a structure for the case studies. This is because this tool excels in uncovering requirements and is often employed to help designers create design briefs. In this case, it could help the researchers critically review the current situation of makerspaces, especially their relationships with users/makers. In this paper, results from two case studies – one from the UK and one from China – will be discussed to identify key similarities, differences and challenges of their current approaches and practices.

The case studies in this research include observations and semi-structured interviews with staff and users of makerspaces. The entire case studies aim to cover three different types of makerspaces: 1) well-established makerspaces, 2) community-based makerspaces and 3) makerspaces that are part of other organisations, e.g. museums, libraries and co-working spaces. Each category will include good examples from the UK and other countries. The interview questions were designed based on the four categories of PACT Analysis (see table 2). In this paper, the former two types were investigated: Remakery as the community-based one and Xinchejian as the well-established one.

The interview questions were designed based on the literature review findings. It was observed that existing studies tended to focus on facilities and benefits, e.g. types of machinery and values makerspaces offer to users/communities. While there were a number of studies that investigated relationships between makerspaces and makers, they rarely explored the *'empowerment'* occurred in this type of space. To complement previous research, this study will focus on: 1) *how makerspaces could empower people to make*; and 2) *how makerspaces could empower people through making*. The former focus on how the design of the space could attract people and encourage them to engage with making activities, while the latter concentrates on how the outcomes of making (e.g. artefacts) could benefit people beyond those who are directly engaged with the makerspaces. In this

research, the interviewees include both the staff and users of the makerspace responding to the questions (see Table 2).

Table 2 Questions for owners, staff and users of makerspaces

Subjects	Sub-categories	Interview Questions
People	Maker identity	• Please describe key characteristics of current users.
	Access/entry barriers	• What might prevent potential users from engaging with this makerspace and how could these barriers be reduced?
	Relationship	• How would you describe the relationships between makerspace and users?
	Perception of social impacts	• What social impacts do you see/expect from engaging with makerspace?
Activities	Desirable value propositions	• What are the core values that may attract people to engage with this makerspace?
	Service design	• Please describe main services provided by this makerspace.
	Functionality & Aesthetic value	• To what extend does the design of this makerspace enable and/or hinder the delivery of these services?
	Emotional value	• To what extend does the design of this makerspace enable people to socialise, share ideas or express themselves?
	Encouragement/ Communication	• Please describe how to encourage/communicate with people to get involved in the activities provided by makerspace
Context	Identity	• Please describe how you feel in the makerspace.
	Empower to make	• Please describe activities designed to help people gain creative confidence to make things.
	Empower through making (impacts)	• Please describe how this makerspace was designed to reflect the characteristics of the surrounding community. • What role might this makerspace play in fostering creativity of people in local community?
	Partnership / collaboration	• Are there any opportunities for this makerspace to collaborate and/or work in partnership with other organisations? (e.g. pop-up events or co-working)
	Social enterprise	• Please describe the main purpose of engaging with makerspace and your potential contribution to community.
Technologies	Physical & digital	• Do you have a digital platform? If so, how does it compliment the services you provide physically?
	Facilities	• Please suggest desirable technologies that makerspace should consider to provide.

3.1 Case Study 1: The Remakery, London

3.1.1 The Organisation

Locating on Lilford Road, London, The Remakery occupies an entire basement of a residential building (see Figure 1). The organisation was originated based on the ethos of reusing waste and reclaimed materials. Its main service is providing space and a means to make things, which enable people to create positive changes to their community and the environment.

Figure 1. The main entrance of The Remakery. Source: The authors

One of its key roles in the local community is facilitating conversations about environmentally conscious lifestyles. The Remakery was founded as part of a positive movement initiated by the Lambeth Council in response to anti-social problems in the local areas, e.g. squatting. The organisation was originally funded by the Lambeth Council and greatly benefitted from the rise of social enterprise in London and surrounding areas.

The main challenge of most makerspaces including The Remakery is the sustainability of their business models. The organisation has tried several business models. Originally, all members were its stakeholders. Since then, the business model has continuously evolved to respond to the needs of the people. According to the interview, at one point, users could *'come and go as they please'*. Subsequently, the engagement was reduced to the point that the organisation hardly had any users. As a result, several countermeasures had been taken. For example, in 2015-16, it had introduced the membership system to attracted wider audiences and enhanced the commitment. At present, The Remakery is a non-profit, multi-purpose and inclusive makerspace where key decisions are made by the committee including its resident makers. The organisation itself has also constantly evolved. A project called *Remaking, The Remakery* started in 2018 is underway. The aim is to regenerate both the interior and exterior space into an appealing and multi-functional makerspace.

3.1.2 The People

According to the interviews and observations, The Remakery attracts both male and female users from the immediate community with making skills varied from mid-range to high. Most of them are around 20 to 40 years old. The place has a clear target audience. It serves a niche group, namely people who are interested in remaking/reusing waste and reclaimed materials, as well as those who are environmentally conscious. The organisation gathers and provides recycled/reclaimed materials that are free for its members to use (see Figure 2).

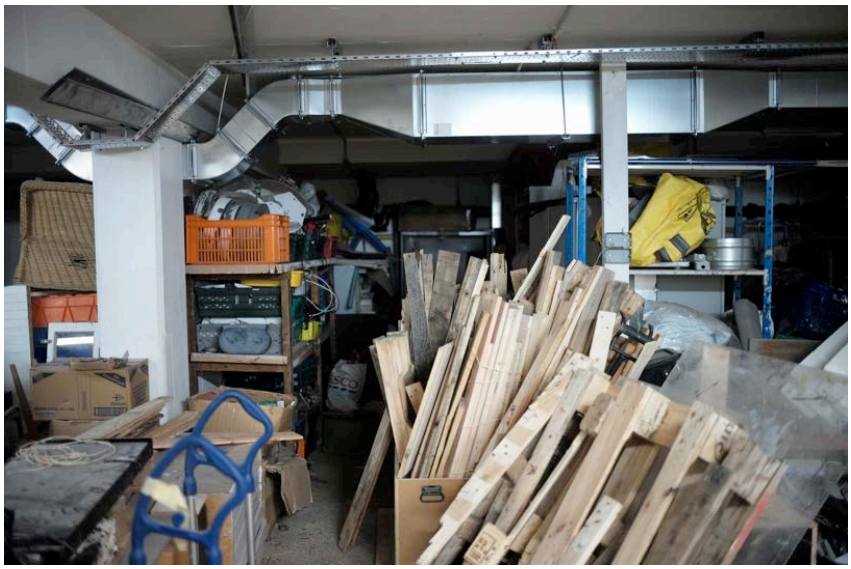

Figure 2. The reclaimed materials were stored at the back of makerspace. Source: The authors

The Remakery goes beyond serving individual makers and supports local social enterprise by letting out some of its space – for example, Incredible Edible, which focuses on urban farming. Moreover, some of the resident makers run their own social enterprise. The organisation also welcomes both makers and non-makers to its events which aim to facilitate conversations about environmentally conscious lifestyles to the public (see Figure 3).

The volunteers have made significant contributions to the sustainability of the organisation. According to the interview, 90% of operation and management were done by volunteers, including many resident makers. It was observed that many people started engaging with this place as members to get access to the facilities and materials to work on individual projects. The organisation is keen to develop long-term relationships with people. Hence, it tries to get members involved in other activities other than their work so that they would not lose interests and leave after their projects have concluded. By engaging them in on-going projects/activities, the organisation is able to build a long-term relationship with members. For instance, many of resident makers have taken on other roles in the organisation – for example, the interviewee used to be a resident woodworker. Now he is the Director of Communications, Marketing & PR. The key is to create *'reasons to engage'*.

Figure 3. The event held by Incredible Edible at The Remakery. Source: Edible Lambeth

The organisation acknowledges that *"not everyone wants to get their hands dirty"* . However, people can still be part of the positive changes without involving in hands-on making activities. Thus, public engagement goes beyond *'physical'* elements to include *'cognitive'* elements through conversations – it is about being part of the community. The interviewee commented that The Remakery is expanding its territory from *'making'* to *'thinking'*.

3.1.3 The Activities

The Remakery is perceived as a place for not only making, but also socialising. Most physical activities include, but not limited to, timber crafting and homeware making (Figure 4). The organisation considers itself as part of a community. According to the interview, people came here for the skill sharing and peer-to-peer learning, which is a key reason for some members to join in. It was observed that the resident makers play a key role of giving advice to members with less making experience to help them build up skills and creative confidence (Figure 5). Members could also get peer support. Besides, some training courses offered by the resident makers are in a relatively low price, which appeals to some members.

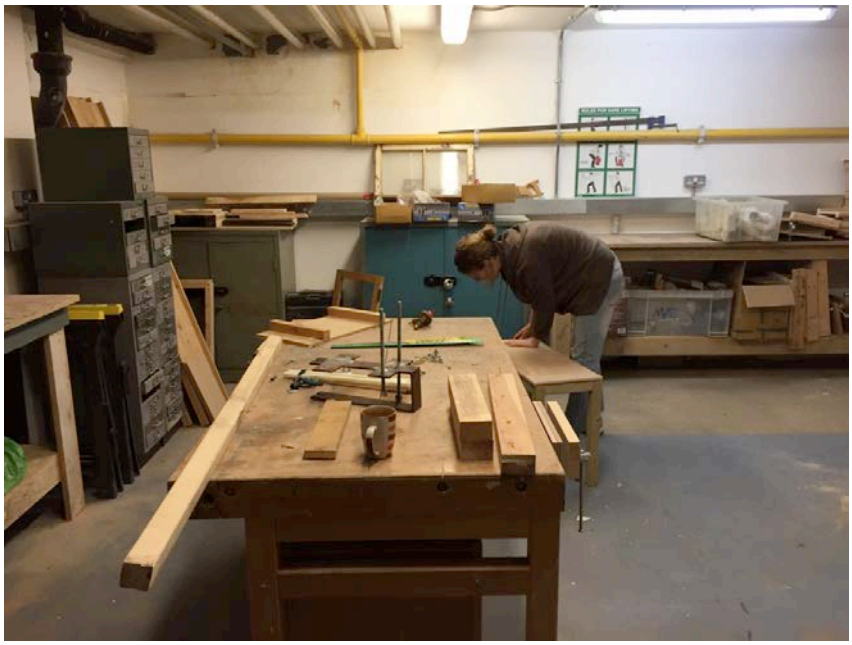

Figure 4. A new member is crafting her bench. Source: The authors

Figure 5. The experience resident maker (left) mentors a new resident maker. Source: The authors

Activities in The Remakery are rather informal and such social culture, to some extent, benefits from the flexibility of the physical space. The layout and interior are constantly evolved to respond to the requirements of the community/users – for example, the interviewee described the character of the space as *'fluid'*. The space is shaped by what people want to make, and the informal atmosphere encourages people to exchange ideas. It was observed that space gives a 'multipurpose' vibe (see Figure 6). Furniture is informally arranged and can be moved around easily. The space is not *'fixed'* to a specific purpose or layout. A designated social space is provided for people to socialise. According to the interviews and observations, conversations and socialised activities also take place the making areas.

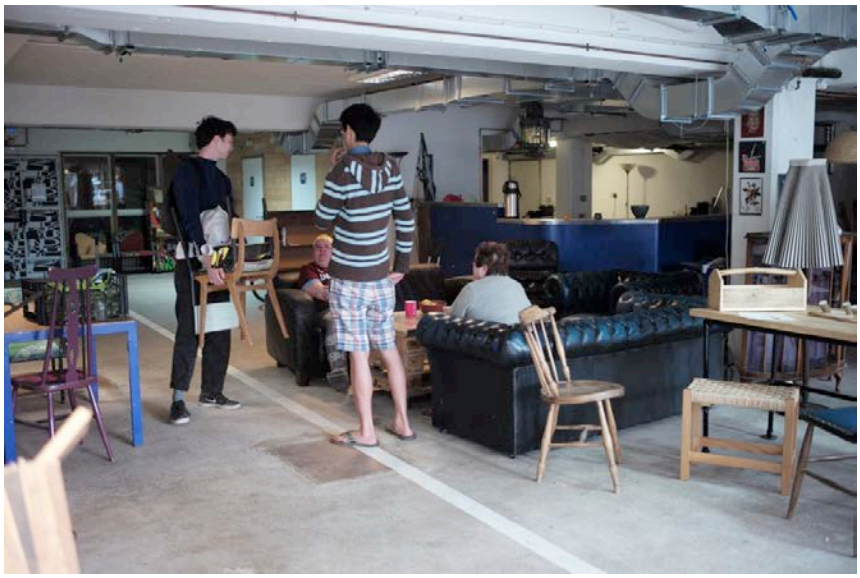

Figure 6. The social space is designed to promote casual conversations and socialisation. Source: The authors

3.1.4 The Context

From the organisation's perspective, it offers actionable options for local people to take positive actions in regard to their neighbourhood and the environment. At The Remakery, making is considered as a means to 1) get people thinking creatively, 2) engage them in conversations about reclaiming/reusing waste, and 3) offer them opportunities to play a more active role in transforming their community and/or tackling environmental issues. As a result, The Remakery works in collaboration with several social enterprises (e.g. community garden) in their area and organise various events/activities to engage local residents, e.g. holding a discussion panel to find out the requirements of the community and how to address them through making. Currently, the organisation is in the process of building more co-working space for social enterprises that share common interests in an environmentally conscious lifestyle. Additionally, many resident makers also use this space as a catalyst and platform to build up further networks. For example, one of the resident makers has set up a social enterprise to help people with anxiety and other mental health problems through woodworking activities. (See: City Woodwork: http://citywoodwork.co.uk)

3.1.5 The Technologies

The organisation has started to focus on its digital platform, which is not only for outreaching, but also creating narrative for wider attention. The website has recently been updated.

3.1.6 Key Lessons Learned

Although The Remakery focuses on a niche group, it managed to attract a wide range of audience (both individuals and social enterprise) who share common interests in reusing waste and reclaimed materials and an environmentally conscious lifestyle). Having a **clear ethos** and personable ways of **keeping people engaged** with the organisation are crucial to the success of relationship building. It successfully *'empowers people to make'* through a number of activities, e.g. mentoring, training, informal peer-to-peer learning and idea sharing. The well-designed service (e.g. providing free reclaimed materials) and the multipurpose space play an important role in supporting these activities. The Remakery also successfully in *'empower people through making'*, as the organisation sees its services as '***actionable options***' for people to make positive changes to their local community and the environment. The interview with the Director of Communications, Marketing & PR noted that although The

Remakery started as a place to make objects, the organisation is now interested in **making *'people'*** by giving them skills and providing them job opportunities. For instance, many members and resident makers use this place as a **platform** to start their own social enterprise. Its core value can be summarised as *"to spark the environmentally conscious lifestyle through making"* and to generate the conversation of (re)making. By seeing *'making'* as the skill and way of thinking to tackle issues, this can be seen as fostering creativity.

3.2 Case Study 2: Xinchejian, Shanghai

3.2.1 The Organisation

Xinchejian is currently located at 28 East Yuyuan Road, Shanghai. The organisation claims to be the first hackerspace in China (see: https://xinchejian.com/about-2/). It provides space for different types of making and supports a variety of projects – ranging from physical computers to digital applications. Moreover, it organised various workshops, which enable people to meet, share ideas together, and learn making skills from each other.

The development of this makerspace went through three phases (namely Xinchejian 1.0, 2.0 and 3.0) in three separate locations. Originally, Xinchejian started off as a not-for-profit organisation. It was initiated by David Li as Xindanwei in 2010. Later on, co-founders Ricky Ng-Adam and Min Lin Hsieh joined to create Xinchejian 1.0 (located in 76 Anhua Road, Shanghai) with an out-of-pocket investment. It opened to the public in 2011 before moving in 2012. After the first phase, the organisation received an additional financial boost from 12 stakeholders (mainly very active members) which enabled the space to continue. Most of the projects could be classified as prototyping high-tech, e.g. a telepresence robot. During the second phase, Xinchejian's witnessed significant growth in the number of users. Subsequently, the paid membership system was introduced. Full-time staffs were hired to manage the space. Xinchejian 3.0 was launched in 2014 after the relocation to 28 East Yuyuan Road (see Figure 7). Since then, at any one time, 100 members (renewals and new) are members of the makerspace. The organisation also received several visits from local politicians. At present, the organisation is registered as a private company and has received both corporate and local government sponsorships.

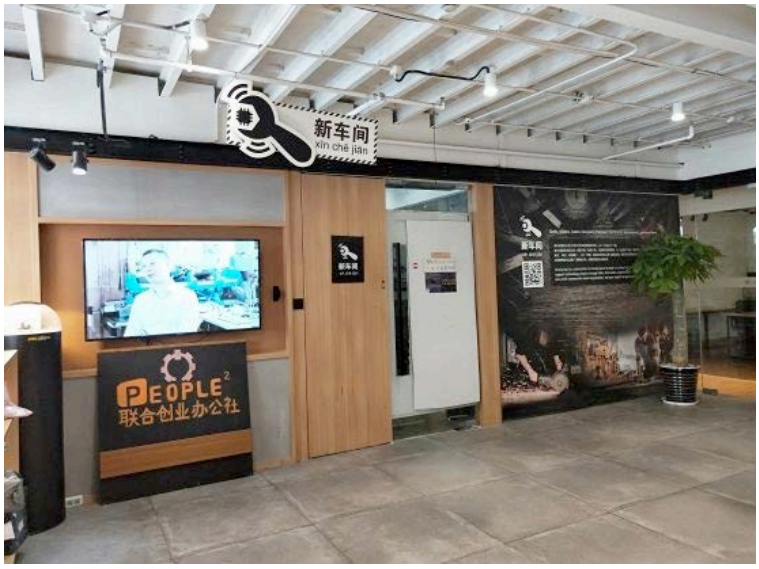

Figure 7. The main entrance of the current location of Xinchejian. Source: http://www.oiponline.cn/blog/xinchejian-hackerspace-shanghai

3.2.2 The People and Activities

According to the officially website and the interview, the majority of users and staff of Xinchejian are male (approximately 70%). Generally, participants are 21-35 years old, most of which are university students and working professionals. Currently, there are 345 active members in the Xinchejian's WeChat group, which is a popular social media platform in China. This makerspace welcomes all types of members regardless of their making skills, knowledge and/or professional backgrounds. It is described as a supportive space for people with curiosity to explore freely without restricted mechanism. The core value is to reward people with pleasure generated through creating and (peer) learning. The makers are inspired and develop their skills further by observing and/or talking to others.

Xinchejian is 24/7 accessible (except holidays) for its members. The organisation is considered as a space of freedom, exploration and diversity. Users can benefit from its tools, space and community. With ¥200 (around £20) per month, the members have access to storage space (for an extra monthly fee), basic and advanced making tools (e.g. drills, hammers and laser cutters). Moreover, this makerspace is sufficiently large to accommodate many groups and activities including the Wednesday evening weekly open house techtalks. Workshops organised by both staff and users have helped the organisation financially. For instance, one of the resident makers and the partners have successfully organised a series of workshops for their 'Precious Plastic' project, which focuses on recycling and remaking the plastic waste through an innovative way (see Figure 8), for a number of years. Additionally, Xinchejian has supported some of its resident makers to build up viable businesses with their creative projects – it has helped one of the resident makers found a business called 'Vincihub Helicopter Simulator' (see Figure 9). However, the workshops attendees do not have much in common with their daytime users. Based on the interview, Xinchejian mainly attracts specific individuals rather than immerses itself into the immediate local community.

Regarding the outreach strategy, Xinchejian provides a session called 'Open Nights', which is held at 19.00 every Wednesday (see Figure 10). The organisation invites many entrepreneurs, hobbyists, scholars and makers to share their making experiences, ideas and achievements. The event is free of charge and open to the public. Generally, each session attracts around 30-40 participants – both Mandarin Chinese and English speakers. The aim is to bring together people, who are interested in DIY and hacking, to share ideas and introduce Xinchejian to a wider audience.

Figure 8. Precious Plastic hopes to encourage the public to pay more attention to the environment issues. Source: http://www.oiponline.cn/blog/xinchejian-hackerspace-shanghai

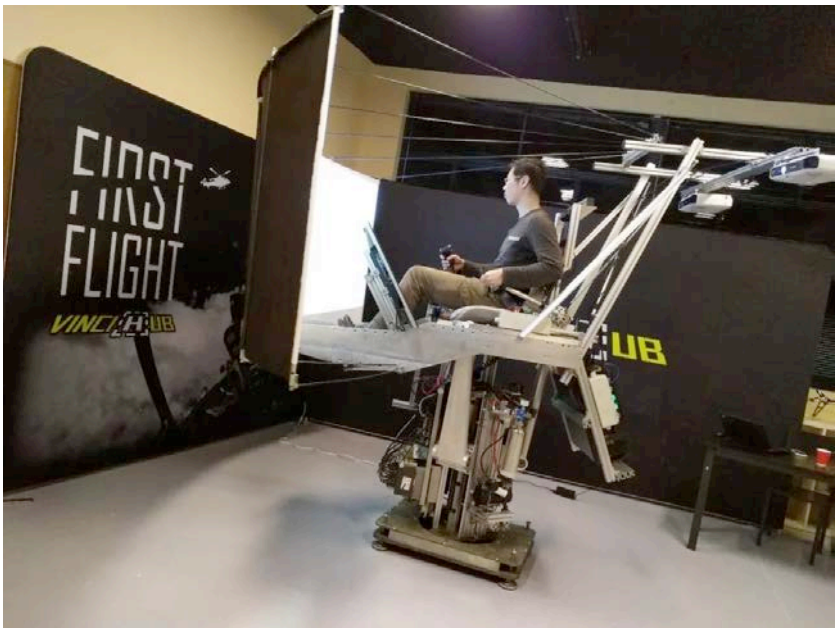

Figure 9. Vincihub Helicopter Simulator project is designed to help non-experience people to learn flying Helicopter in 10 hours. Source: http://www.oiponline.cn/blog/xinchejian-hackerspace-shanghai

Figure 10. Open Nights session. Source: http://www.oiponline.cn/blog/xinchejian-hackerspace-shanghai

3.2.3 The Context and Technology

It was observed that makerspace in China has largely benefited from the lower costs of manufacturing facilities, tooling, components and materials comparing to those in the UK and the USA. This might be one of the main reasons that makerspace in China attracts many foreign makers. This situation has helped Xinchejian become widely known globally. Locally in China, its promotion benefits from its social media platforms (e.g. Weibo and Douban). However, the social presence has been inactivated since 2017 with the disappearance of permanent paid staff. Today, the organisation has put more focus on its official account on WeChat since it is more influential in China to announce weekly tech-talks and events.

The success of Xinchejian has led to significant growth of hackerspace and makerspace throughout the whole China (Dongfangzaobao, 2012). However, the biggest barrier that prevents local people to join Xinchejian is the language. In an attempt to be multicultural, all management tasks are carried out in English. As a result, the organisation requires its staff

(especially those in managerial roles) to use English fluently. According to the interview, Xinchejian had previously introduced the bilingualism system and had tried to integrate itself into local community. Nonetheless, these attempts were not successful, since its business model has been targeting individuals rather than focusing on community development.

In order to expand, Xinchejian expresses a need to help its members make a living through making. Nevertheless, the organisation acknowledges that it is difficult to make a living out of making alone. To address this issue, the interviewee stated that Xinchejian has considered prepaid retainer contracts to help 'making a living through making' possible by reducing financial pressure of the maker community (see: coderbunker.com).

3.2.4 Key Lessons Learned

In China, Xinchejian provides the first model of how the makerspace initiates, operates and sustains itself for close to a decade. Although it serves a larger group of makers than that in The Remakery, it does have a **clear focus** in terms of its target audience. It accommodates diverse groups of users including digital artists, fashion designers and makers with a non-tech background. Interestingly, people love to use digital technologies and applications in some way. While the organisation welcomes everyone who is interested in making, it excels at identifying makers who could potentially *'make a living through making'* and helping them set up their social enterprise and/or commercial businesses. In order to work with this group of users smoothly, Xinchejian has put several **measures** in place, e.g. embracing multicultural users, carrying out all management tasks in English and offering prepaid retainer contracts to ease the financial pressure of its members. It successfully *'empowers people to make'* through a number of activities, e.g. the low-cost membership fee, 'Open Nights' sessions and various workshops. The organisation also makes it possible to *'empower people through making'* even though its approach is rather different from that of The Remakery. Xinchejian focuses on supporting individuals through business developments rather than working with the local community. In many ways, the organisation does show interests in ***'making people'*** by helping them make a living through making. Many members have used this place as a **platform** to launch their careers. Some of their projects have been scaled up and commercialised, e.g. Tokylabs (https://tokylabs.com/). Evidently, the organisation has helped foster creativity at the individual level. It combines the digital applications and early start-up businesses which are key areas the Chinese government is keen to support nowadays (Chen, 2018). In Xinchejian, the nature of support goes beyond hands-on making activities (e.g. providing tools and materials), as its services also incorporate innovative making, entrepreneurial thinking, and business development.

4 Discussion and Conclusion

The preliminary results show that makerspaces have strong potential to be used as a means to foster creative citizens. At present, makerspaces have successfully attracted a wide range of audiences, e.g. governments, educators, creative disciplines and community developers. Subsequently, makerspaces have been used to support a number of positive initiatives, e.g. STEM education, social innovation, community development projects and public engagement programmes. Previous studies revealed that the main motivation of most makers was to *'express'* themselves and *'be creative'*. Hence, makerspaces could be more widely utilised to support more diverse audiences. The case studies, which focused on relationships between makers and makerspaces – especially how makerspaces could empower people, suggested that the organisation must be clear on 1) ***'who'*** they intend to empower and 2) ***'how'*** they intend to empower them. Both cases showed that having a **clear**

target audience has helped them tailor their offers to suit their needs. While the Remakery focuses on helping people who are interested in using waste and reclaimed materials, work toward their environmental goals, Xinchejian concentrates on helping individuals who are interested in making a living through making. Despite their different philosophies, both organisations see themselves as a *'platform'*. Interestingly, their focus has been shifted from making artefacts to *'making people'* – in other words, enabling them to achieve their goals (e.g. helping them set up their businesses). In order to empower people effectively, several measures have been put in place. Whilst many of them can be classified as *'**practical**'* matters, e.g. providing suitable training, several of which focus on *'**social'*** aspects, e.g. creating a social space for users to socialise, network, share ideas and learn from each other. These initial findings have provided useful directions for the next stage of the study. In the following stage, the team will explore what role co-design could play in helping makerspaces *'make people'* or enable them to achieve their goals more effectively. Additionally, the study will investigate how to get people participated in co-design as a means to engage them with hands-on creative activities.

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Learning tactility from Bauhaus: Educational pedagogy of Lasyo Moholy-Nagy

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In design, sensual experience, where the sense of touch is coupled with vision, plays an important role in building designers' internal knowledge. Therefore, many design schools put emphasis on perceptually grounded experience, especially in the first year curriculum. Foundation of perceptually ground experience as formal educational concept goes back to Bauhaus, which is one of the most important teachings of Bauhaus that still influences today's design education. However, in contemporary practice, especially with the use of the computers, perceptual grounded experience in design studios highly decimated and mostly limited with visual experience. Moreover, tactile experience has often been neglected in comparison to visual experience both in design practice and research. With this regard, this study analyses tactile experience in design based on the teachings of Moholy-Nagy. Educational approach of Moholy-Nagy on tactility will be elaborated within the perspective of grounded and embodied cognition. This paper aims to contribute to the understanding of tactile experience in design within the frame of embodied perspective.

Keywords: embodied cognition, tactile experience, design education, Bauhaus, Moholy-Nagy

1 Introduction

Sensual experience, where the sense of touch is coupled with vision, is encouraged in design education with regards to its contribution to various aspects including perception and crafting skills. Although architects emphasize hands on experience, cognitive aspect of the sensual experience have been merely investigated. Tactile experience in design has been studied in research that are related to crafting skills, sketching, drawing, physical model making and various hands-on activities. Nonetheless, this study focuses on the cognitive aspects of tactile experience in design, which supports internal knowledge production and the intuitive behaviour. The example of this notion can be found in the educational pedagogy of Moholy-Nagy, who was the head of metal workshop in Bauhaus Dessau between 1923-1928 and founder of the New Bauhaus in Chicago in 1937. Nagy was an artist and he considered design as an intuitive practice. More than any other professors in Bauhaus, Moholy-Nagy specifically emphasized the role of tactile sense and systematically proceeded it in his workshops with various tactile exercises.

Recent studies in cognition suggest that our body and environment are integral parts of our cognitive system. Understanding these theories is important in order to examine the role of

hands-on experience in design. Therefore, in this study firstly, cognitive theories that acknowledge bodily experience will be briefly explained with related empirical studies in different fields. Further, design studies with similar cognitive approaches will be referred. Eventually, an educational design pedagogy that emphasizes the tactile experience will be analysed within this approach.

2 Embodied and Grounded Cognition

One of the contemporary theories that appreciate the sensual experience as a part of the cognitive system is grounded cognition. Perceptually grounded cognition theories assert that simulation, situation and bodily states are the central actors of the cognition. Studies demonstrate that perceptually grounded experience plays a significant role in learning and problem solving (Clement 1994 Stephen and Clement 2007, Barsalou 2008, Black 2010). Clément's (1994) study indicates that expert scientists rely on their physical intuition rather than abstract equations while solving a physic problem. He describes the term "imagistic simulation", which refers to a dynamic temporal mental simulation of an event that subjects create based on their physical intuitions during problem-solving activity. Stephen and Clement (2007) also found out that imagistic simulation plays an important role in the novice problem-solving process as well as experts. Similarly, Black (2010) implies the importance of perceptually grounded experience in learning. He (2010) states three steps to learn something, (1) a perceptually grounded experience (2) learning to imagine the perceptually grounded experience (3) Imagining the experience when learning from symbolic materials. According to him for a complete understanding of something, it is necessary to build a mental perceptual simulation of it (Black, 2010). Simulation is one of the central accounts of grounded cognition research. Briefly stated, simulation is the revitalization of perceptual, motor and introspective states obtained during our interaction with the mind, body, and environment through experiences (Barsalou,2008).

On the other hand, another cognitive theory that links perception with direct sensual experience is embodied cognition. In embodied cognition theory, simulation plays a significant role in social cognition and aesthetic experience. Especially, studies in the field of neuroimaging and neuropsychology link embodied experience and aesthetic experience (Freedberg and Gallese 2007, Jola et. al 2012, Umilta et. al 2012, Kirsch et al. 2013, 2016). In both dance and related performative art, simulation of observed moments is generally linked to the part of aesthetic experience (Kirsch et. al. 2015). Freedberg and Gallese (2007) claims that the reason we appreciate art is partly due to the embodied experience that we simulate in the brain. Empirical evidence from studies indicate that aesthetic appraisal of static figurative visual art (Freedberg and Gallese, 2007) and abstract art (Umilta et. al. 2012) might be related to embodied simulation. Umilta et.al (2012) demonstrates that observation of a static abstract art activates the relevant motor areas in the observers' brain. According to Umilta et. al (2012), the visible trace of cutting action in original painting helps participants to simulate an embodied experience, which representational lines do not afford the same experience. Additionally, these studies indicate that embodied simulation is related to physical abilities and can be enhanced by training and experience. Cross et. al (2011) demonstrates that observers' aesthetics evaluation of dance moments is related to their physical ability to produce movements. Participants like the movements more, which they considered to perform more difficult. Jola et.al (2012) demonstrate that observers' visual experience related to aesthetic appreciation of dance movements as well as a physical

experience. Kirsch and Cross (2015) show that with certain physical training, apprehension of a dance performance of the participants has increased due to the fact that they can imagine themselves doing certain dance figures.

Existing literature points out that perceptually grounded experience plays an essential role in the development of cognitive, spatial, motor, social and aesthetic skills. Nevertheless, there are a few studies that investigate the design cognition within the frame of embodied perspective. Groth (2016) emphasizes the importance of haptic and tactile experience in decision making during design and craft making. She found out that emotions are key to the decision-making process and they are linked to haptic and tactile experience (Groth, 2016). Moreover, Groth and Mäkelä (2016) suggest that students' previous material experiences gathered through the body, guided them in material explorations even before the actual physical manipulation of the materials began. Gursoy and Ozkar (2015) encourage the making as an integral part of the thinking process in design, in contrast to the general distinction between thinking and making. Thinking through the material also has been granted in craft practices' research (Mäkelä 2007; Nimkulrat, 2009). Still, those realms are merely investigated in design practice, especially within the perspective of embodied cognition. The main motivation of this study is to contribute to filling this gap by investigating tactile experience within the perspective of embodied and grounded cognition.

3 Learning from Bauhaus

3.1 Sensory experience in Bauhaus

The foundation manifesto of Bauhaus was to create a unique mode of production by combining arts and crafts instead of industrial production (Denel, 1979). The school aimed to gather all the creative workers such as architects, sculptors, painters, and raise them as craftsmen at the same level. Accordingly, the educational program of the school had various workshops, where students were able to directly test tools, materials and production techniques. This working environment provides students to experiment with visual and spatial outcomes of their ideas continuously (Ozkar, 2007). Above all, what makes Bauhaus still unique was to teach a design approach instead of how to design. This learning style does not focus on how a particular object is done in a certain way; in a much broader sense, it focuses on the act of making as an integral part of the design process (Ozkar, 2007). This approach, which was founded and developed in Bauhaus was continued by former employees who went to the US, Britain, and Russia after the Bauhaus was closed. Lasyo Moholy- Nagy was one of these educators, who lead the preliminary courses and various workshops in Bauhaus Dessau between 1923-1928. Later, he founded the New Bauhaus in Chicago in 1937, which was named as "Institute of Design" in 1938, and directed it until his death in 1948. He was also an artist and known as her activities in a range of fields such as painting, film, typography, sculpture, graphic design, stage design, and photography.

Moholy-Nagy's educational pedagogy aimed to support internal knowledge production and intuitive behaviour. According to Nagy, design education should deal with internal conditions, not external ones. He believes in a process-oriented education model, in which students can communicate their inner transformations (Findelli, 1990). Nagy states that "Basic sensory experiences - gained by these exercises - undergo development and intellectual transformation, and later are brought into relation to other experiences. It is not possible to skip any stage inexperience, though it may sometime appear desirable. From the first

inarticulate experience, the whole life is constant growth. Therefore, it is indispensable, in human development, to pass through all the stages of elementary experience in every field of sensory activity. Little by little man find his way of expression and find his form" (Lasyo-Moholy-Nagy, The New Vision, 1947, p.23). Therefore, the sensory experience was an essential part of his courses. More than any other professor in Bauhaus, Moholy-Nagy specifically emphasized the role of sensory experience and systematically proceed it in his workshops with various exercises. Figure 1 shows one of the sensory exercises "Smell-o-Meter" by his student Charles Niedringhaus. In these exercises, six tubes are used to mix six different odors, and an electric fan blows the odor towards the nose opening.

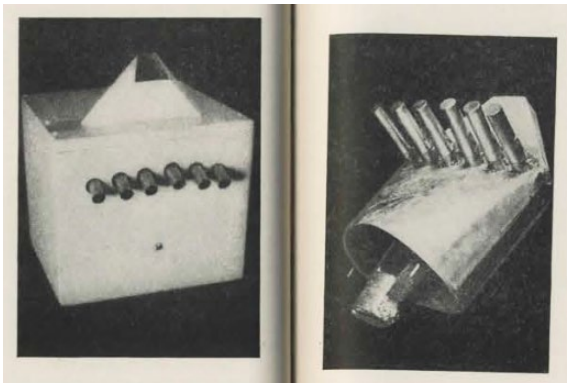

Figure 1. Charles Niedringhaus,-Smell-o-Meter (The Second Semester New Bauhaus, from The New Vision 1938, p.34.)

3.2 Moholy-Nagy pedagogy on Tactility

Nagy focused on sensory experiences, enrichment of emotional values and development of thought in the preliminary courses. Nevertheless, he puts specific emphasis to the sense of touch in his book New Vision, where he explains his educational pedagogy in Bauhaus and Institute of Design. According to him sense of touch more than any other can be divided into number of separately sensed qualities, such as pressure, pricking, rubbing, pain, temperature and vibration (Moholy-Nagy,1947). Nagy gave students different tactile exercises in his studio. In these exercises, students used to gather various materials, so that they could experience different senses with them as much as possible. Some of these senses were related while some of them had contrasting sensations. After this experience with the materials, the students created their own tactile charts. Figure 2, shows the tactile chart developed by Nagy's student Willy Zierath in Bauhaus 1927 fall semester (Smith, 2006).

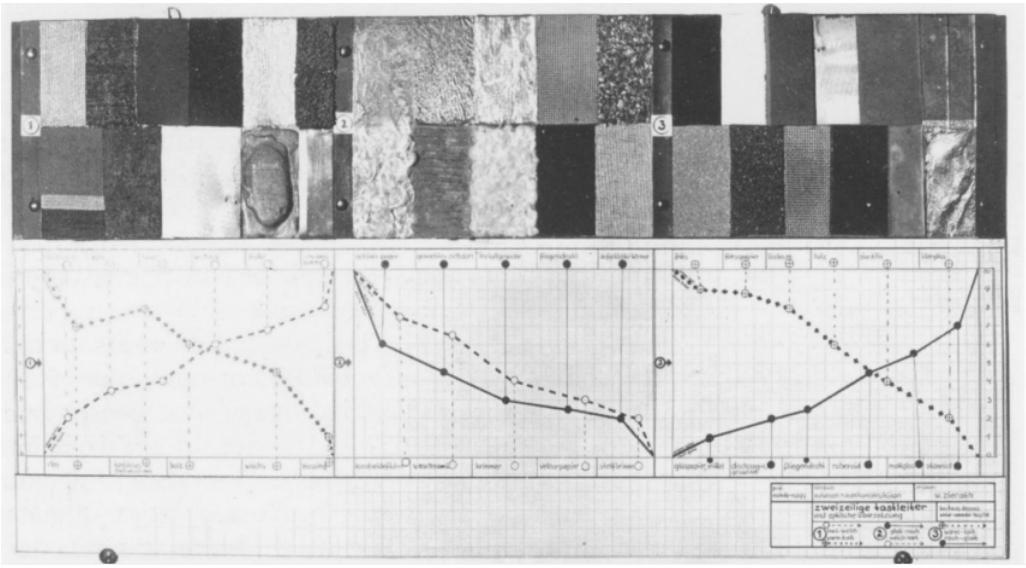

Figure 2. Willy Ziereth. "Zweizeilige Tastleiter Preliminary Course, winter semester 1927-1928. Courtesy Bauhaus-Archive Berlin. Smith, 2006, p.14).

Zierath chart on a flat surface uses three set of columns which two of the row in each column consists of materials with different tactile properties and below in the last row there are graphs showing tactile values on grid paper. Zierath called these chats “optical translation”, which he translates the “tactile values” of the materials above into a visual language, which exhibits the sense of touched materials (Smith 2006). The compositional grid examines the tactile values such as hardness/ softness, smoothness/roughness, dryness/wetness by means of systematically combined materials for example man-made and natural, raw and fabricated ones. Furthermore, tactile values translate to subjectively recorded reactions into a “touch diagrams” these could be referred to again later on.

In the same preliminary course, Otti Berger, who was later graduated from Bauhaus as textile designer, created a textile chart that consists of thread triangles made of silk, rayon, velvet, wool, organic and chemically treated cotton that diagonally replaced on a metal strip and coloured papers (Figure-3). This chart shows early interest of Berger in the role of touch, who later developed theoretical writings about the primary role of tactility in cloth (Smith, 2006). Berger’s tactile chart examines visual and tactile values in one piece. Therefore, it may be differentiated from Zierath pure touch diagram. However, both studies aimed to build a systematic tactile experience and examine the different properties of tactility. These exercises were subjective test as Moholy-Nagy states and did not have a scientific aim, but they all enabled the emergence of useful results in the field of technology or art and rehabilitation of visually handicapped people later (Moholy-Nagy, 1947). As other sensory experiences, the purpose of the tactile exercises was to contribute to designers’ inner knowledge transformation.

Figure 3. Otti Berger, Moholy-Nagy's preliminary course, Touching board with threads, 1928 (from Bauhaus Women: Art, Handicraft, Design, p.63).

Nagy had pursued the same pedagogy in Bauhaus Chicago and Design Institute. In the preliminary course, Nagy used to introduce students with basic components of design to prepare them for following workshops. After successfully completing preliminary course, students were used to attend five workshops in Institute of Design, including object design, textile, colour, light and modelling workshops (Figure 4). The first exercises start with sensory experiences with fingers the tactile tables. After that students combine different textures among tactile charts. The form of the tactile charts was not defined for any specific problem. The only criteria were that the surfaces to be tested were sensible to the minimum stimulus. Therefore, the form of the tactile charts was unique to every individual and each of them was reflecting an original idea. Some of these charts not only stimulated fingertips but also muscles and joints. For example, student work developed on twisted plastic in (Figure 5) was designed to allow for different circulation, such as the ascending and descending finger movements (Moholy-Nagy, 1947).

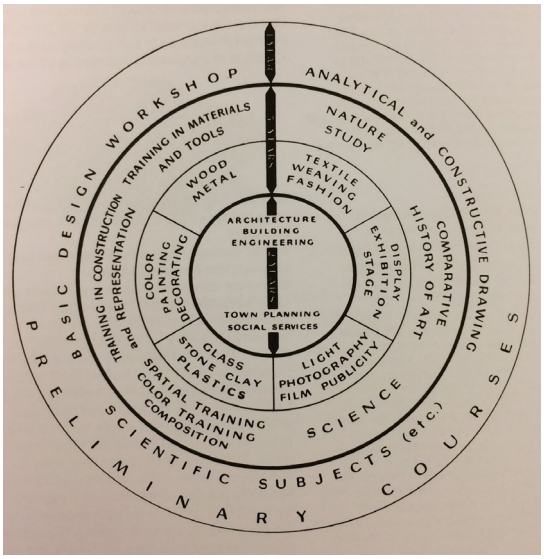

Figure 4. The New Bauhaus Educational Programme (The Bauhaus: Weimar, Dessau, Berlin, Chicago, p.194).

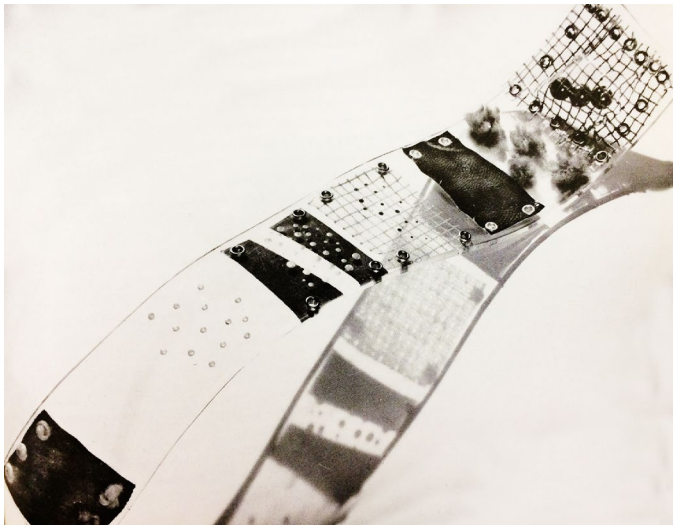

Figure 5. Tactile chart by O Robert Brownjohn, Institute of Design 1944, Bend plastic (from Vision in Motion, p.77)

After completing their tactile charts and segregate the different qualities of touch sensation with their fingertips, students were obliged to make a hand sculpture. By means of this, they were able to register the function of hands that is to catch, to press, to twist, to feel thickness, to weigh, to go through holes, etc. All these exercises in the first part of the training was integrated with the following workshops and classroom, which was another unique aspects of Design Institute curriculum.

Long before the theorization of “perceptual learning” theorizes in cognition studies, Nagy applied a perceptually grounded learning pedagogy in Bauhaus and Design Institute. Especially James and Eleanor Gibson's ecological perspective of perception, which is assumed as an important pillar in the theorization of embodied cognition, suits very well to Nagy’s educational system. According to Gibson, perception improves discovering new information about an object rather than building up new definitions (E. J. Gibson, 1978; E. J. Gibson & Spelke, 1983; Adolph and Kretch 2015). In the Design Institute, students did not add new descriptions but they seek for the new possibilities of the materials, mediums and their bodies. His education was focused on all the sensory experience without prioritizing the visual sense. He investigated the potential of the tactile experience in whole haptic system as an integral part of our cognition. As Gibson (1979) claims perception of an object involves not only perception of the visual characteristics of that object, but also involves what the object affords (Gibson, 1979; Goldstein 1981). Similarly, Nagy’s exercises intuitively help students to be aware of the affordances of the entities that will guide them for their following practices.

4 Conclusion

For Moholy-Nagy, primary aim of the sensory experiments was to develop a unique way of expression for each individual. He considers all stages of sensory experience as the ground for personal development. Nagy intuitively knows that sensory experience does not only contribute to crafting skills but also skills associated with thinking, perception and intuition. Nagy was aware of the technological means of his age. According to him, the key of the era was to "seeing everything in relation" (Moholy Nagy, 1947, p68). At present new digital tools, which are introduced by rapidly developing technology, have affected intuitive practices such

as design as well. The problem is; how design education adopted and reflected these changes. In this context, I believe that some of Nagy's teachings, who interpreted his age very well, are still valid despite changing technology and will guide us in shaping the future of design education.

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Light as Tool for exploring Three-Dimensional Form

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Designing physical objects for mass production involves a range of critical considerations. Product designers are dependent on carefully defining criteria before developing and integrating properties and physical shape into product solutions. The act of aesthetic assessment of qualitative form characteristics in physical models constitutes a fundamental part of creating desirable design solutions for the end user, complementing assessments through screen-based digital renderings. Traditionally, product designers have developed creative methods for aesthetically driven form development, utilizing both 2D and 3D tools. However, the conscious use of light during this activity is rarely mentioned as part of the creative toolbox. In this context, are we aware of what fundamental impact light has on our perceptual capabilities during aesthetic assessment and fine-tuning of a physical model? During an extensive series of light experiments, different constellations between artefacts from various stages of the product design process and different light sources were explored. Through a series of photo- and video recordings this study has enabled the understanding of how light influence our visual assessment of physical objects and their construction in product design. These observations support the idea that light may be utilized quite extensively in order to support the designer to explore and to build control and insight through careful observations during aesthetic judgement.

Keywords: Light, product design, observations, perception, aesthetic assessment

1 Introduction

1.1 Illumination and three-dimensional form

In this paper my ambition is to build awareness of the essential role of light as a form-describing medium during the process of refining visual shape of an artefact or product, being part of a simulated design process. During a series of experiments producing an extensive series of photo- and video recordings, different constellations between objects from different stages of the product design process, and different lights sources, have been facilitated.

This paper takes a hands-on, analogue, explorative and experimental approach to light, in the intersection between design research and art. It focuses on light as a form-describing phenomenon, excluding colour as such.

A key interest then is assessing light's impact through visual perception, addressing the designer's need of aesthetical assessment of form. In this study, I consider only physical objects related to the small object scale, not the large architectural scale. Methodologically,

following a research by design approach, a product design process is simulated using models from different stage of completion. All in all, the paper investigates light from a practical, human-centered and designerly perspective.

1.2 Problem / objective

After teaching product design on Bachelor and Masters level for an extensive period of time, I see that both students, teachers and researchers within the field of product design seem in need of strengthening insight, experience and skills in the process of aesthetical assessment of advanced form. I see this as a concrete need in my teaching and is at the heart of the experimental study presented below.

The argument I pursue is that by strategically revitalizing product design as design-research discipline, it is important to adopt alternative educational tools and methods that can help strengthen the quality of product design education, including aesthetic language and articulation.

My previous work, *Light and Shape – Exploring Light as Form-Describing Medium During the Product Design Process,* Skulberg (2017) took up an analytical approach to the design process focusing on how light may perform as a form-describing tool on an introductory level. In this paper, I shift focus to describing results from in-depth light experiments, with focus on how experimental and explorative research on light may enhance understanding of three-dimensional form. My hope is to develop understanding of the influence light has on our perceptual capabilities and form assessment abilities. Further, my intention is to manifest ways this understanding might inspire designers, artists and researchers to develop a more conscious approach to light while assessing physical form in artefacts and product concepts.

2 Context of the study

2.1 Agency of the designer

Regarding the agency of the designer, what is the fundamental purpose of using light to enable a state of aesthetical form assessment? In her PhD thesis *Mediating Sunlight: Sensing Solar Cells*, Anker (2016) states that, while being professional designers, our challenge is to create affect in a way that attracts people's attention and affection.

After all, in our quest for aesthetic appeal, we strive to achieve qualities in products that enhance the use experience and are aesthetically attractive, of which the latter require a certain minimum of aesthetic sensitivity.

Assessment of form in product design does not only apply to visual aesthetic assessment, but also to the broad field of semiotics. In *Design for Product Understanding*, Monø (1997) discusses the creation of Gestalts, and object's inherent vocabulary of expression, as well as the importance of tailoring visual perception to product's intended expression.

In *Design och productutveckling*, Lundequist (1995) stresses the importance of assessment of design being an inherent part of a cyclic or iterative process, enabling the designer to relate to the given design brief from a client.

A product design process is typically undergoing both divergent and convergent thinking, where an initial multitude of ideas and sketches are synthesized into a solution through a reductionist approach. In his book *Design Thinking,* Rowe (2008) presents procedural aspects of design thinking, through an iconic model of a design process consisting of the

following stages: *Analysis - Synthesis - Evaluation - Communication*. Our study focuses in particular on the evaluation stage, connecting to both divergent and convergent mindset (Lawson 2006).

2.2 On light as tool

Historically, photography is the result of the shift to the embodied observer (Crary 1990). When regarding light as a tool, the history of photography links light as both a natural phenomenon and creative tool to practice. Drawing as a representation technique was replaced by photography during the 20th century, giving photographers the ability to document our physical world with impressive realism and detail (Benjamin 1931) and (Flusser 2000). Relating to observation as method, the three-dimensional – or trans-plane - image is discussed by Schrøter (2014). Live observation through both human eyes constitute stereoscopy, providing the observer with a fully embodied experience.

Today, modern photography provide designers with the most advanced tools to capture and communicate visual impression that strongly stimulate our sensorial apparatus, producing enormous amounts of visual richness. These tools enable us to closely observe and document advanced three-dimensional form.

When studying light as phenomenon, one easily acknowledges the challenge of comprehending the complex nature of light and how light influences our daily life activities. However, from our own experience in academia, it seems that within design education, light is rarely considered as an important or crucial aspect of cognitive experience of physical form, or during the process of assessing aesthetic qualities in object form.

By acknowledging that light is crucial for design activity, my starting point has been to investigate light as creative tool for designers while being in model building mode, as part of the product design process. Relating to this, the basic purpose of visual perception is to enable the recognition of object attributes and characteristics (Cuttle 2008).

Based on a large number of international publications, journals and conferences, the research survey and PhD-course *Nordic Light and Color* (2012) show that neither light nor color are any large issues in international research related to human-scale objects.

Today, several research societies perform multi-disciplinary research on light and color, exemplified by *The Light and Colour Centre*, at *Dept. of Architecture and Technology, NTNU,* having developed two high quality laboratories, ROMLAB and Daylight Laboratory.

There exist only very few well equipped lighting laboratories around the world, and both these are ranged as rather unique and internationally important assets, involving architects, interior architects, artists and physicists, but no designers.

In the doctoral thesis *Light Modelling in Architectural Spaces*, Zaikina (2016) discusses the phenomenon of *light modelling* applied to the smaller object scale, described by how light reveals or conceals the depth, shape and texture of an object by changing the directivity, eliminating or accentuating of shadows and contrast. Furthermore, Zaikina argue that light modeling represent the degree to which light describes 3D objects so their contours, shapes and details are clearly visible.

One observation constitute an interesting approach to physical form. In their paper *Dynamic Visualization in Three Physical Dimensions,* Rowe and Morrison (2009) argue that "*The use*

of fixed points of multi-colored light to simulate motion and image is not new. The television is a good example. The brain smooths over the gap between the dots, actively creating (subjective) information where there is none."

This statement has triggered us to regard physical surface as information. Furthermore, this idea triggered us to explore effects initiated by a relative movement between object, light source(s) and observer's eye(s).

2.3 3D form aspects

Today, there is a relatively small body of literature discussing and describing principles of three-dimensional form on the human-related object scale. In *Principles of Form and Design,* Wong (1993) discusses the relation between 3D form and materiality and texture. Wong also discusses basic principles for creating visual balance and harmony in design, and the vital importance of the designer being able to control three-dimensional form through spatial understanding. In *Three-dimensional Visual Analysis,* Akner-Koler (1994) creates a form-taxonomy by systematizing the overwhelmingly broad specter of physical form into a hierarchy of fundamental form categories. Kohler demarcates basic form elements and their properties by dividing them into four sections: *Basic visual elements (volume, plane, line, point), Dimensions of elements, Proportions, and 3-D primary geometric forms.*

While being inspired by this approach, I have extracted a set of fundamental basic form elements, focusing on and utilizing two divergent categories: *geometric* and *organic* shape.

I have done so to cover the broadest possible matrix of form idioms typically found as basis for form development within product design. The following form characteristics are described by Akner-Koler as fundamentally important, qualitative properties of shape, and they constitute an inspiring starting point for the development of the physical models:

- Symmetry versus asymmetry
- Convexity versus concavity

In addition to these form idioms, Wong has a strong emphasis on *surface structure* and surface *texture* as qualitative properties, of which both have constituted an important focus during my model building.

3 Research methodology

3.1 Means and methods

By taking an explorative and experimental approach, my aim is to produce a body of knowledge through observations in a controlled manner in laboratory settings. This work follow research by design methodologies through:

- Descriptive reasoning based on first-person observation
- Generative approach through building tangible artefacts
- Utilizing simulation technique
- Use of nomenclature organized within a taxonomy of form

The study comprises a concrete case study, utilizing a fixed set of means. These means comprise two divergent ranges of physical models developed in order to simulate diverging aesthetical directions, covering a wide specter of physical form. The experiments utilize the

principle of simulation, as these models represent tree different completion stages of a typical generative product design process, simulating a certain duration of time between the models being made. The reason for choosing this approach is that the simulation of a time-consuming design process efficiently reduce the total duration of time otherwise required for this line of experiments.

Structurally, this paper introduce a matrix of form idioms and light sources as means to identify and locate the dynamics of working with light and 3D form in an experimental mode of inquiry, followed by a set of visual images from the experiments defined in the matrix.

Our primary research question is: 'How can the use of light strengthen our understanding of three-dimensional form?' Subordinately, these underlying questions have triggered our experiments:

- How may a relative movement - between object, light source(s) and observer's eye(s) enhance the observer's perceptual experience and ability to build a strengthened three-dimensional understanding of the shape?
- How may tangential exposure of light onto a three-dimensional object form improve the observer's ability to detect imperfections of shape, structure and texture on model, enabling the correction of these?
- How may objects illuminated by condensed light such as bright micro-spots, lines or light patterns give us new three-dimensional information and improve our visual perception and understanding of complex shape?

3.2 Two divergent models

When categorizing form elements and their properties as part of a form-taxonomy, Akner-Koler presents the following three primary proportions a form can assume: *Extensional, superficial and massive.* All our physical models cover to a certain degree all these three proportions, making them applicable and relevant to Akner-Koler's form-taxonomy.

The first category is dominated by geometric idiom (GEO1-3, Figure 1), and the second, being the opposite category, is dominated by organic idiom (ORG1-3, Figure 2). Within each of these idioms, a range of sub-models were developed, simulating three different levels of completion of a typical product design process, described in Figures 1-2. These levels are:

1. An initial form concept phase using a rough *idea descriptive* model
2. A form development phase using a *form descriptive* model, and
3. A product finalizing phase using a fully developed *surface descriptive* model

Figure 1

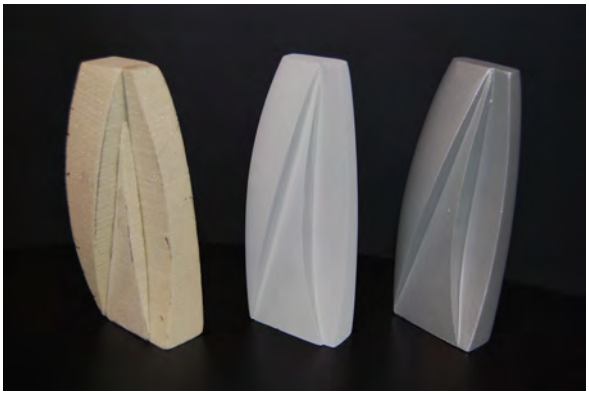


Figure 2

All models were shaped in Cibatool urethane foam with different density properties, according to the model's individual completion level.

3.3 A matrix of form idioms and light sources

In order to explore the effect of light applied to a diverse range of physical shape, a matrix covering both variety in form idioms as well as variety in light sources and light-form configurations was developed. The matrix displays the following potential combinations between models and light sources:

Table 1

Process stage / form category / model level	**A. Sunlight**	**B. Laser**	**C. Halogen**	**D. LED**
GEOMETRIC 1 **Initial form concept phase. *Idea descriptive model***	GEO1SUN Spatial configurations: Linear – Black box with variety of filters	GEO1LAS Spatial configurations: Variations over 'Spot cloud' mode	GEO1HAL Spatial configurations: Linear – Black box with filter	GEO1LED Spatial configurations: Spherical 'Light flow' (360°) + black box
GEOMETRIC 2 **Form development phase. *Form descriptive model***	GEO2SUN Spatial configurations: Linear – Black box with variety of filters	GEO2LAS Spatial configurations: Variations over 'Spot cloud' mode	GEO2HAL Spatial configurations: Linear – Black box with filter	GEO2LED Spatial configurations: Spherical - 'Light flow' (360°) + black box
GEOMETRIC 3 **Product finalizing phase. *Surface descriptive model***	GEO3SUN Spatial configurations: Linear – Black box with variety of filters	GEO3LAS Spatial configurations: Variations over 'Spot cloud' mode	GEO3HAL Spatial configurations: Linear – Black box with filter	GEO3LED Spatial configurations: Spherical - 'Light flow' (360°) + black box
ORGANIC 1 **Initial form concept phase *Idea descriptive model***	ORG1SUN Spatial configurations: Linear – Black box with variety of filters	ORG1LAS Spatial configurations: Variations over 'Spot cloud' mode	ORG1HAL Spatial configurations: Linear – Black box with filter	ORG1LED Spatial configurations: Spherical - 'Light flow' (360°) + black box
ORGANIC 2 **Form development phase. *Form descriptive model***	ORG2SUN Spatial configurations: Linear – Black box with variety of filters	ORG2LAS Spatial configurations: Variations over 'Spot cloud' mode	ORG2HAL Spatial configurations: Linear – Black box with filter	ORG2LED Spatial configurations: Spherical - 'Light flow' (360°) + black box
ORGANIC 3 **Product finalizing phase. *Surface descriptive model***	ORG3SUN Spatial configurations: Linear – Black box with variety of filters	ORG3LAS Spatial configurations: Variations over 'Spot cloud' mode	ORG3HAL Spatial configurations: Linear – Black box with filter	ORG3LED Spatial configurations: Spherical - 'Light flow' (360°) + black box

Table 1 plots two axes, where the vertical axis constitutes the levels of completion within both geometric and organic form idiom, while the horizontal axis list different potential light sources applicable for experiments. In each combination there is a short comment on how the specific experiment is likely to be carried out, typically describing principle of illumination.

4 The experiments

Due to the explorative nature of my approach, it has been difficult to pre-describe in a definitive and clear manner the succession of the experiments and the precise content of each experiment, as insight builds during observation, and the outcome of one experiment might lead to a change in the following experiment. This approach has strongly influenced both the procedure and the outcome of our study.

Except for those experiments involving sunlight, all light experiments were executed by setting up different configurations of artificial light sources and one separate object form for each experiment in a dark room.

As table 1 indicates, the six basic objects (GEO1-3 and ORG1-3) were systematically exchanged between photo- and video recordings while exploring the perceived effect given from different light sources, as well as exploring different spatial configurations combining different light sources and object forms.

4.1 Two principles; perpendicular versus tangential exposure

Two different principles of light exposure have been explored; perpendicular and tangential exposure. In our research project, perpendicular exposure focuses on the principle of illuminating a physical object by one or more light source(s) using a wide flow of light in a frontal angle to the object surface.

Tangential exposure means that condensed light beams -typically by using a filter or lattice- are falling almost parallel to the surface of the object.

4.2 Black box experiments

Most of the experiments have utilized the advantages of a ‘black box’ (figure 3), having the ability to block out unwanted light using a hinged lid at the top. Referring to the construction of the cabinet, the different light sources were positioned into the opening to the left, while photo camera or video camera were positioned into the opening to the right.

Figure 3

In order to answer the first sub-ordinate research question about relative movement, most of the experiments were executed by putting the object into slow motion using a rotating disc, enabling a full rotation every 50 seconds. This feature was crucial by facilitating the observations comprising static light source(s) and moving object. One constellation that was not possible to obtain in this manner was static object and moving light source(s).

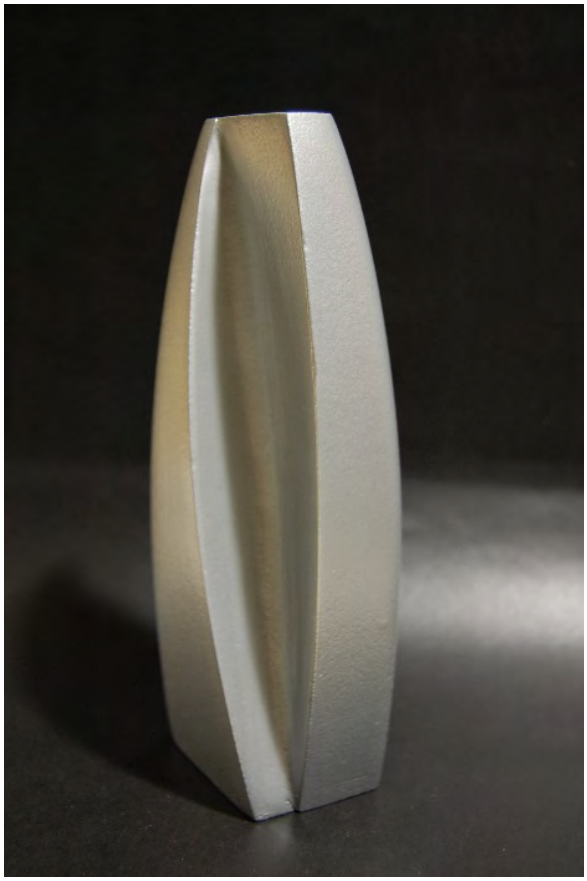


Figure 4

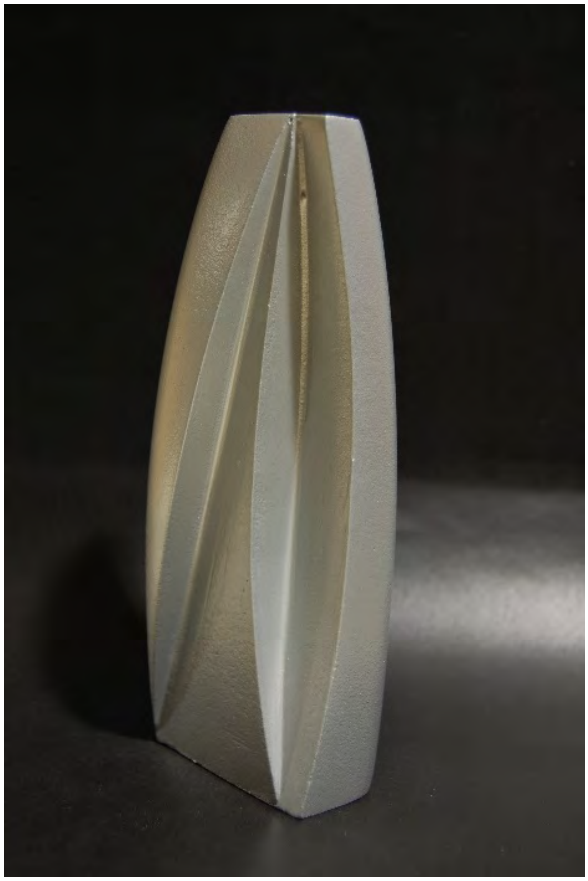


Figure 5

These photos (figure 4-5) from black box experiments describe how the model ORG3 is perceived while being illuminated through perpendicular exposure using a semi-soft light produced from LED. In contradiction to the white box experiments, the cast shadow in these pictures support in defining the underlying surface, and the relation between object and it's surroundings. The shadow cast from the edge closest to the light source adds to the understanding and description of the concavity - or negative volume - of the object form.

4.3 White Box Experiments

As part of our initial experiments aiming at acquiring experience from exploring light, two opposite situations were examined; 'overflow' of light using the white box, versus 'lack' of light, using the black box.

The 'overflow' of light experiments was executed as an opposite configuration to the Black box experiments, by establishing a full spherical illumination of the object. In this experiment, a large Styrofoam box (figure 6-7) with a hollow inner volume formed as a perfect sphere was utilized. A LED strip with a large number of diodes (figure 8) was attached to the inner surface, constituting a 360° light emitting circle.

The experiments utilizing the white box set-up aim to explore the contradiction to the black box set-up, by experiencing how the lack of shadow influence our perception of shape. The white box experiments are appreciated by facilitating valuable insights to how light has limited ability to ‘model’ physical form without any direct or indirect support from shadow.

Figure 6

Figure 7

Figure 8

By making a small hole through the wall of the box Styrofoam box (figure 7), photo captures of each model were enabled through camera and video recordings.

In contradiction to the black box experiments, the overflow of light enabled by the white box evidence how cast shadows are totally eliminated (figure 9-10), producing a week understanding of body volume and also a poor perception of depth of perspective and the relation between object and it's surroundings.

Figure 9

Figure 10

This constellation reveals almost none of the topographic features of the model surface. On the other hand, this constellation produce a rather 'soft' atmosphere that might be appreciated as comfortable to the eye.

4.4 Tangential exposure – sunlight projection & model topography

The second sub-ordinate research question about tangential exposure was investigated by

using two different light sources; observing illumination from the sun - having parallel sunbeams, and by using laser. Both were investigated with and without integrating lattices.

In their PhD course *Nordic Light and Colour*, Matusiak and Anter (2012), discuss the timing of the solar elevation angle in Nordic regions. The term *tangential exposure* in our study correlates to the term *solar elevation angle* in their study. Light perception of ground, landscape, building, terrain and people is strongly determined by the solar elevation angle and the illuminance level. Comparably, in our study, tangential exposure of light strengthens the clarity of visual perception, especially of surface features in complex shapes.

In figure 11, the rig for sun-based experiments is displayed. This box is attached to a rectangular funnel designed to allow only direct sunbeams reaching the object, and to reduce unwanted light.

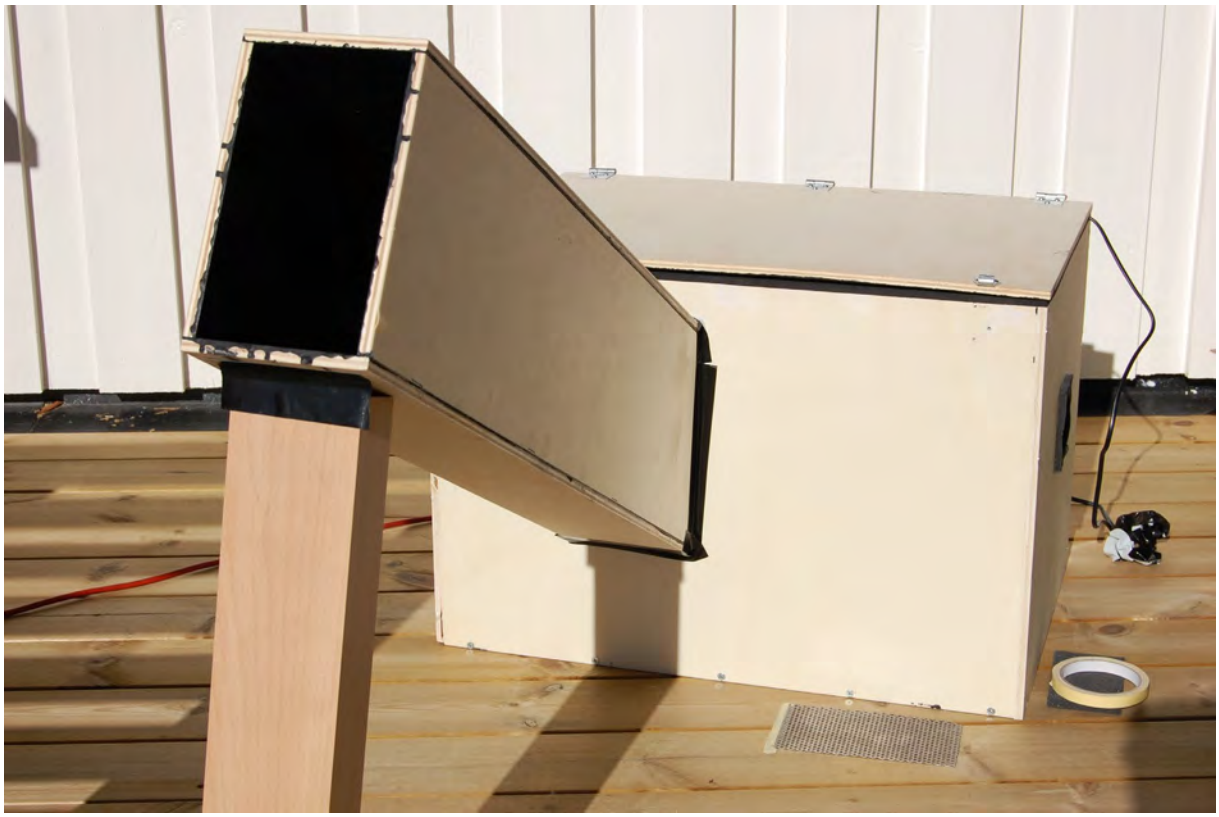


Figure 11

Figures 12-15 display quit clearly how tangential exposure inform visual perception of topography, consisting of both geometric plane surfaces as well as single-curved surfaces.

In the first picture, the sunbeams are almost parallel to the topography of the surface of the GEO1 model, captured in side view.

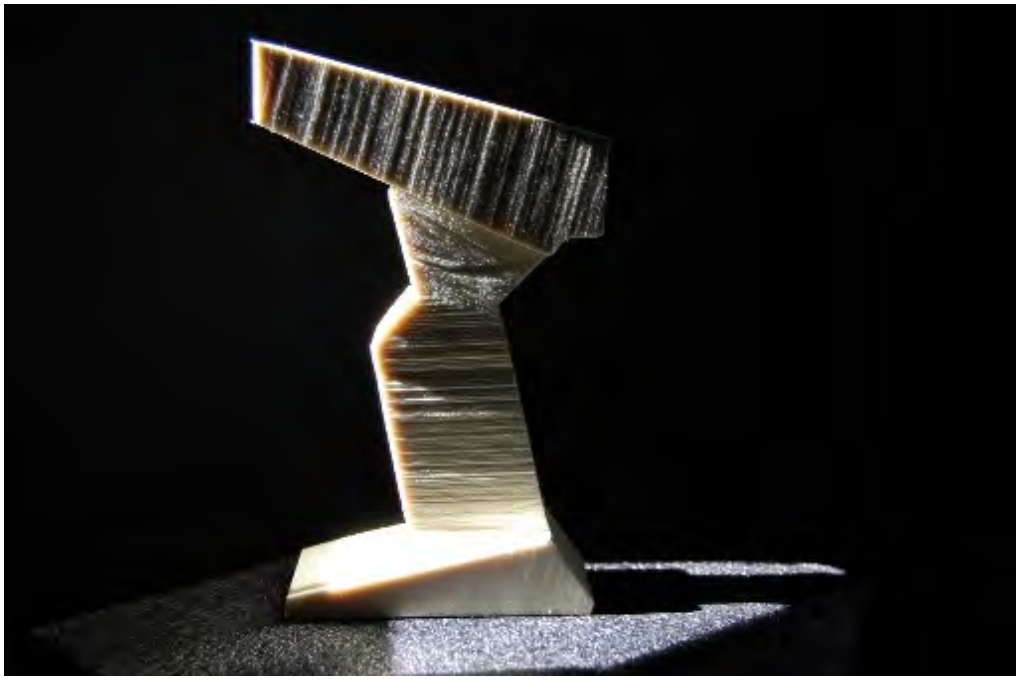


Figure 12

This constellation has an strong ability to reveal topographic imperfections on the surface, simply because this is an initial and rough sketch model. When considering tangible surface as information, tangential exposure obviously seem to have a surprisingly strong ability to convey a large amount of detailed topographic information of the object surface.

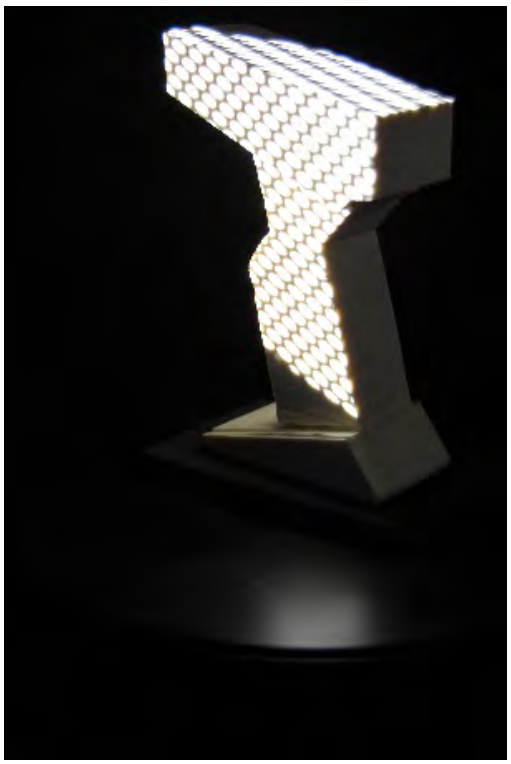


Figure 13

Figure 14

Figure 15

In Figures 13-15, tangential exposure with sunlight is combined with the integration of a lattice with homogenous structure, into the rectangular funnel of the black box. During slow rotation, the illumination of the object's surface changes, giving the impression of the pattern being streched or condenced, depending of the angle of exposure of the sunlight.

4.5 Laser versus sunlight

Our third sub-ordinate research question about illumination using condensed light such as bright micro-spots, lines or light patterns was researched using laser as light source. In these experiments, the surface texture exposed to the laser line changes its appearance quit dramatically when the exposure angle decreases towards zero.

When moving the laser line towards a dead zero exposure angle, the laser line takes a parallel direction to the surface and leaves the surface. In the same instant, just before the line leaves the surface, the visual impression of the surface changes quit dramatically as the surface texture gradually reveals a rather rough, topographic terrain. This new terrain consists of holes, depressions and traces, especially noticeable are those remains from the machined and hand-based building process of the mock-up model.

In the following figures 16-36, all models are illuminated by a single laser line.

Figure 16

Figure 17

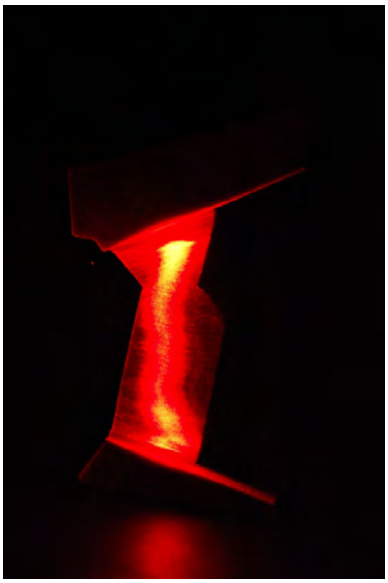


Figure 18

Figure 19

Figure 20

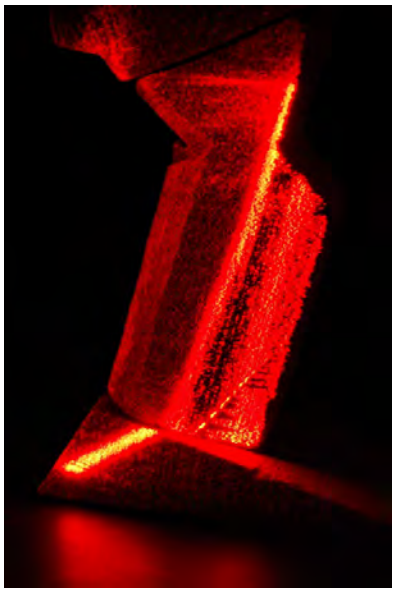


Figure 21

Figure 17 reveal in particular how the foam surface of the GEO1 model reflects the traces of the rotating saw used for cutting the foam blocks during model building.

In Figure 20, a close look at the surface of the upper section of the GEO2 model reveal how the narrow laser line describe the topography by accentuating the rough terrain of the surface.

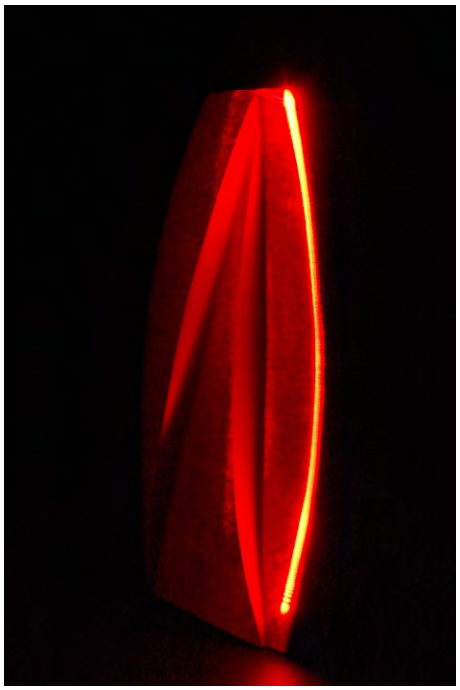
In the same way, in Figure 21, imperfections in the lower part of the model are evidenced, caused by the assembly of quit rough Styrofoam sections during model building.

Figure 22 *Figure 23* *Figure 24*

In Figure 23 and 24 the GEO3 model (figure 22) is illuminated. When carefully adjusting the angle of exposure of the laser line, the slightly curved surface of the upper section of the object is accentuated, and the impression of the curved surface becomes prominent. This particular feature seems to be hard to reveal otherwise.

Figure 25 *Figure 26* *Figure 27*

In Figures 26 and 27, the ORG1 model (figure 25) is illuminated. By following the laser line, it clearly describes the roughness of the surface. The strongly illuminated laser projection onto the surface describe the intersections between the elements which constitute the object form.



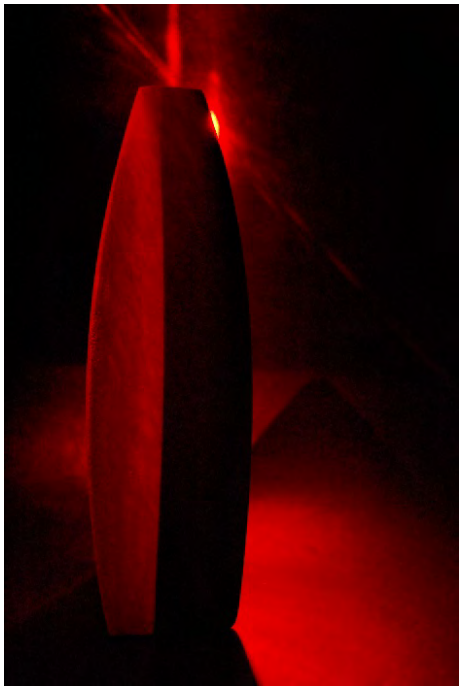


Figure 28 *Figure 29* *Figure 30*

In Figures 29 and 30, the ORG3 (figure 28) model is illuminated. By following the movement of the laser line, the strongly illuminated laser projection describe the intersections between the elements which constitute the object form.

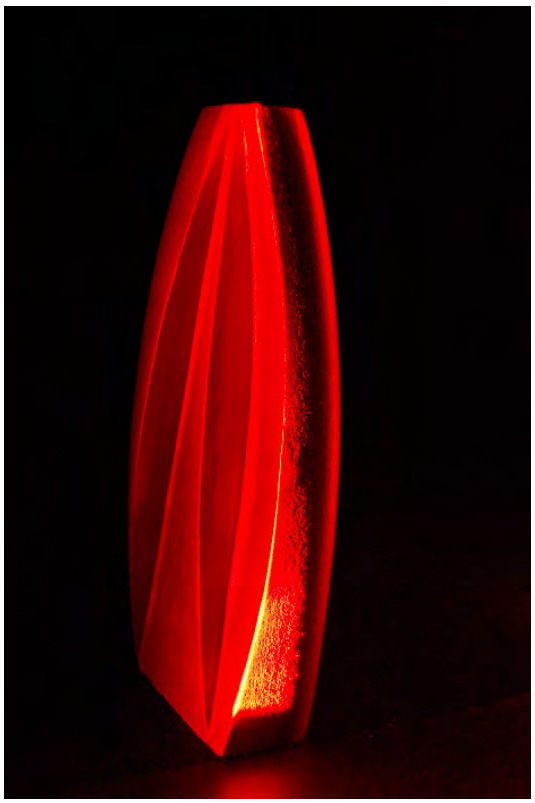


Figure 31 *Figure 32*

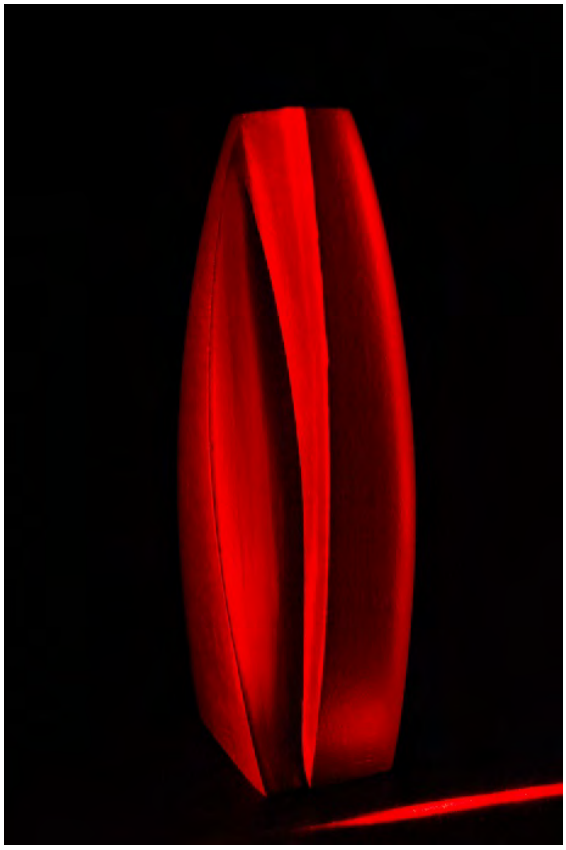


Figure 33

Figure 34

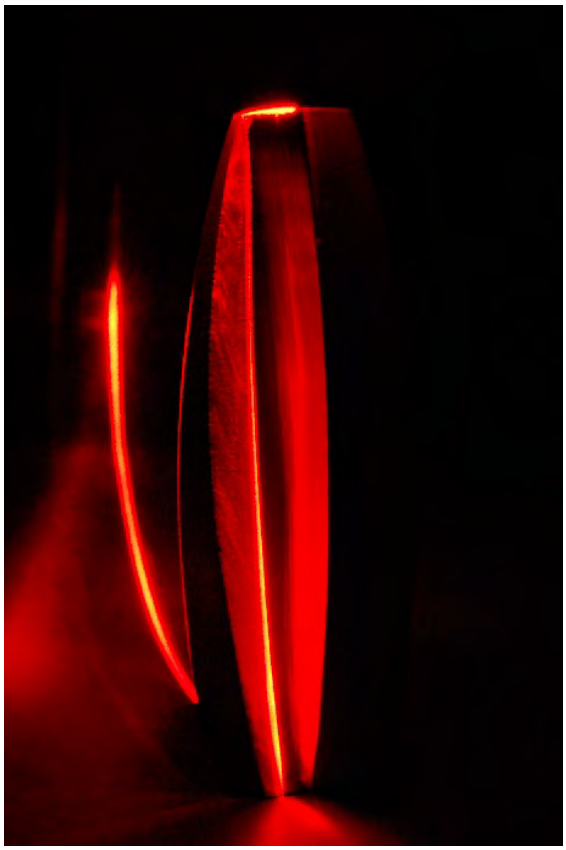


Figure 35

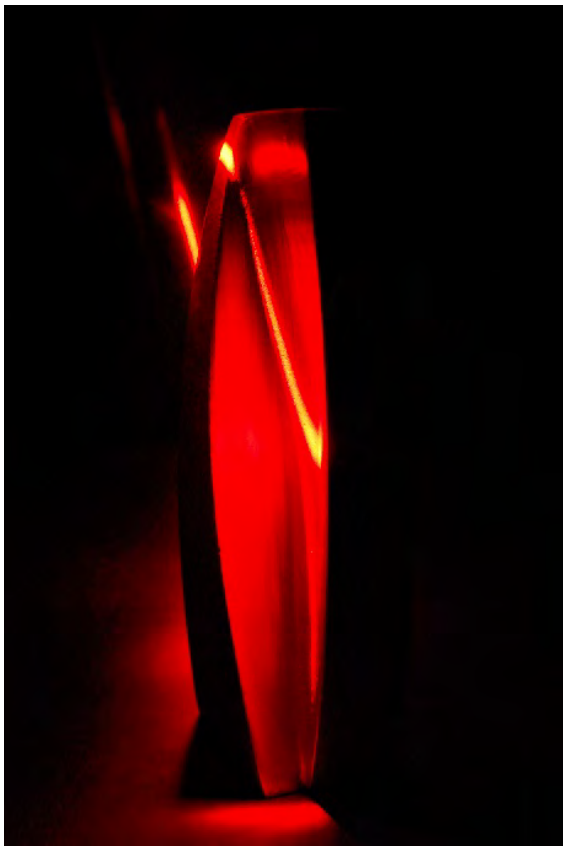


Figure 36

While being a final, surface descriptive model simulating a final stage of the design process, the ORG3 model has a hard and glossy surface with the particular ability to reflect light. Figures 31 – 36 describe how the laser line produce glare which contributes in describing the overall shape of the object form.

4.6 Moving ‘spot-cloud’ projection

In this experiment, a hand-held green laser in ‘spot-cloud’ mode was used. The models - exemplified in Figure 37 - were not rotating, but a relative movement between lights source and object was still achieved as the laser was hand-held, thus achieving a ‘lively’ photographic image of the illuminated surfaces, combined with a long camera exposure.

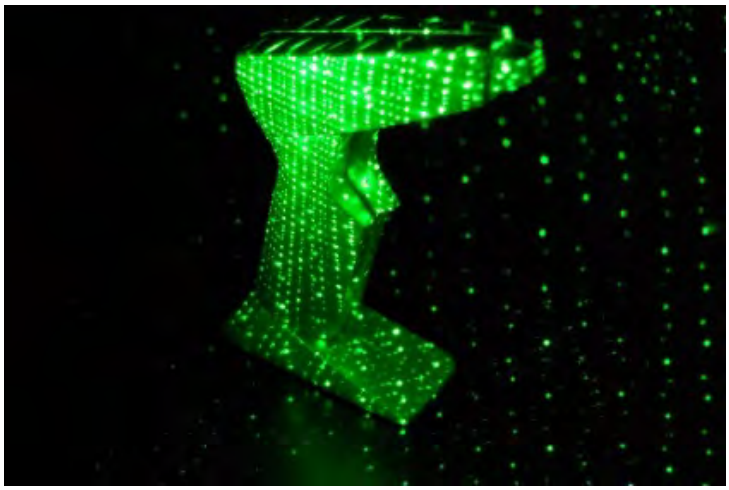


Figure 37

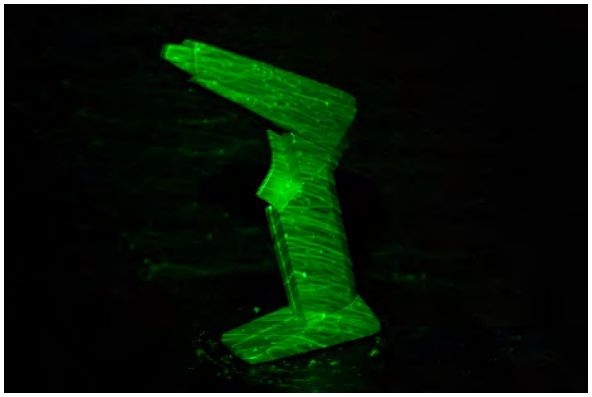


Figure 38

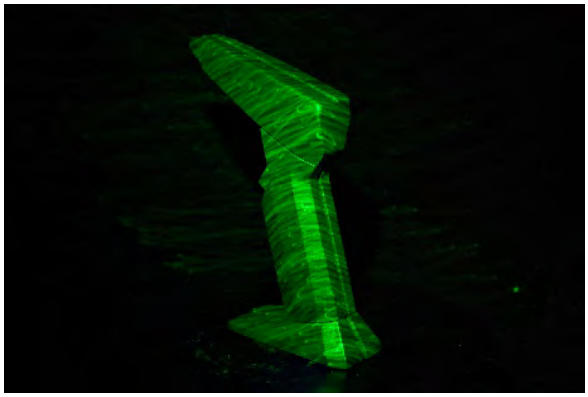


Figure 39

In Figures 38 and 39, the GEO3 model is illuminated. In these pictures, the hand-held laser line was moved rapidly, producing an almost horizontal and linear exposure. Even though this exposure is very minimalistic and reduced, the perception of the geometric sections of the object body is quite clear.

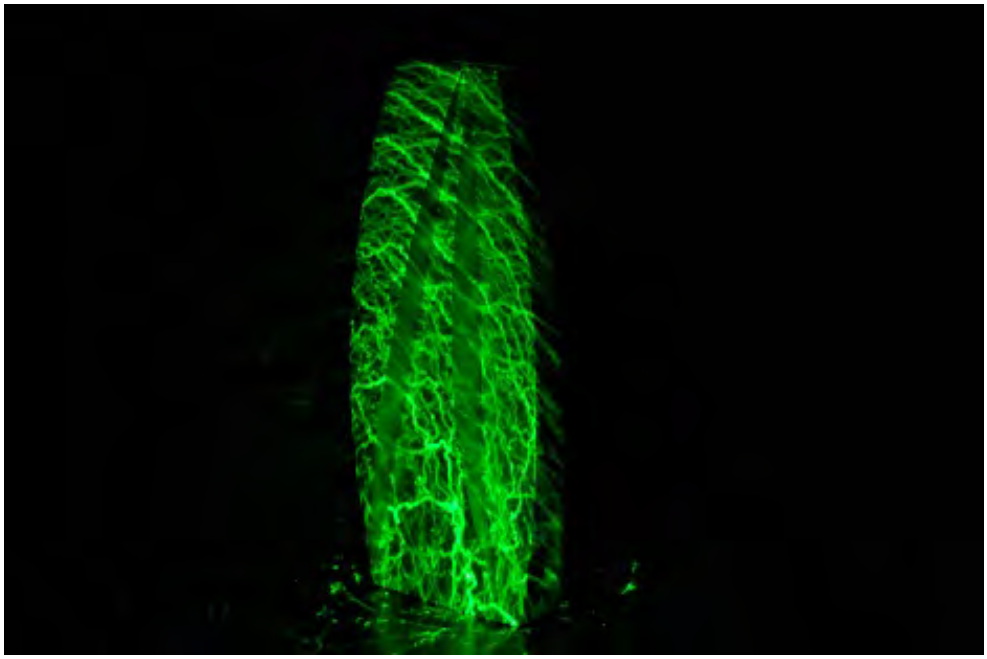


Figure 40

In Figure 40 the ORG3 model is illuminated. In this image, the model is exposed by a rather chaotic and non-structured movement of the hand-held laser, creating a graphic pattern that - at first hand - seems to be non-informative, but after sufficient exposure builds a 3D-shape.

4.7 Moving single laser line projection

By moving the single laser line freely by hand, while at the same time having the shutter open, each movement of pointed light is captured as a graphical pattern onto both the surface of the object itself (figure 43-44), and the background. Illumination intensity in the captured image is a direct consequence of hand's speed of movement.

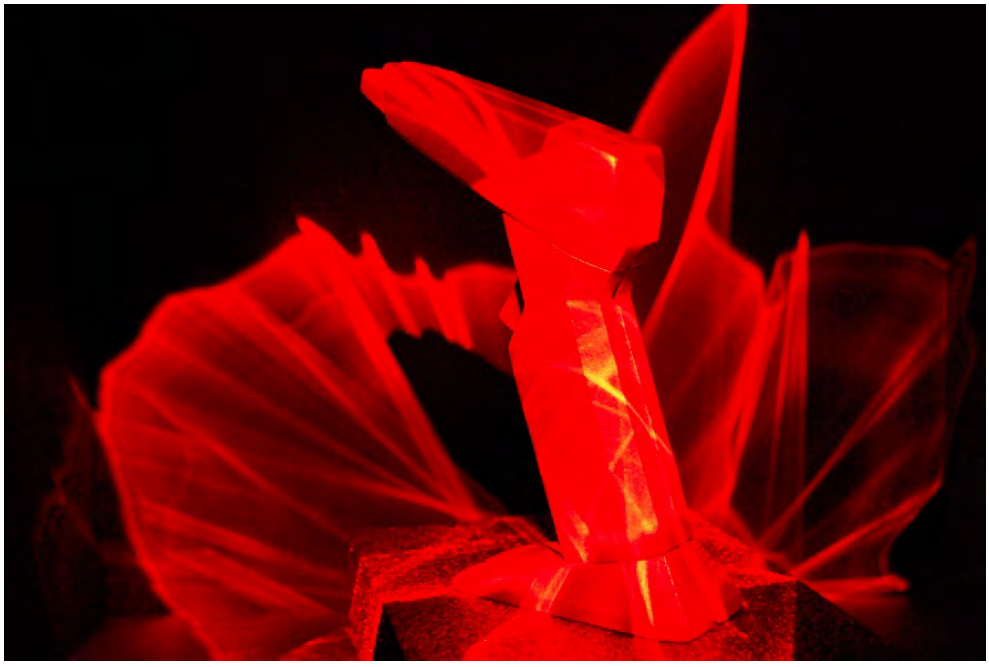


Figure 41

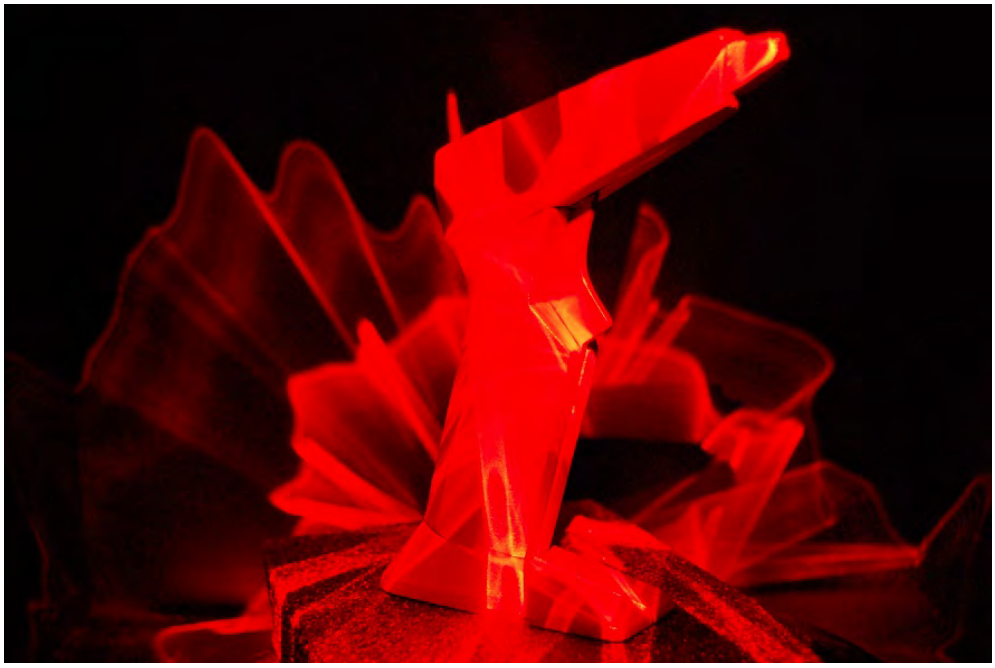


Figure 42

By following this technique, an intriguing picture emerges. This approach accentuates the sections of the object that are illuminated for the longest period of time, but also connects the object form to the surroundings in a spatial manner, as the laser line transforms into becoming a kind of three-dimensional paintbrush. Of all the different approaches during our study, this technique fascinated us mostly, and we see that there is a potential for further exploration on how laser might support spatial understanding of form, but also texture and structure of small-scale model surfaces.

5 Findings and reflections

In the study, different constellations between object and light sources have been staged, producing an extensive series of photo-sessions and video recordings. By taking an explorative and experimental approach, these observations have produced a body of knowledge and a growing awareness of the essential role of light as a form-describing medium during assessment and refinement of visual shape of a tangible artefact.

In my view, the experiment matrix describing the different potential constellations between object and light source(s) displays a novel approach to investigating light.

My key finding is that the visual impact from light exposure depends of the level of completion of the illuminated model. This means that observer's understanding of volume, form and surface structure is dependent on the quality of the given light source. In other worlds, the more defined the model is, the higher influence has the properties of chosen light sources to convey this definition, and to generate the most informative visual perception of the model as possible.

Defining material properties such as density of the building material to volume, structure and surface texture to the desired level of completion is of vital importance for enabling control during model building.

While being part of the real world, I acknowledge the importance of visual dynamism. During the study, I gradually realized the importance of facilitating a relative movement between two or more of the elements implied; the object, the light source(s) and the observer's eye(s). If a movement between two or more of these elements is initiated, the static constellation is terminated, and the visual experience is suddenly highly reinforced by becoming dynamic. As a result, the cognitive understanding of volume, shape and texture of the object is substantially enriched. As a consequence, the use of video format has been valuable for recording these insights, however poorly fitting the academic paper.

When applying tangential exposure of light onto a three-dimensional object surface, the angle of light arrays tend to reveal deviations of shape, structure and texture of the model, improving our ability to detect imperfections, and enabling the correction of these.

Especially while observing complex shapes, typically organic shapes, the advantage of using light spots or spot cloud configurations is prominent. When using laser providing lines or spot patterns / spot clouds in combination with rotation of the object, a new and intriguingly rich visual experience is created. This experience is achieved because the light spots through their relative movement to the surface create the visual impression of a superficial 'membrane' that defines the volume and geometry of the object through visual recognition, but weakening the recognition of texture.

Experience from spotlight configurations indicate that much of the same effect is obtained when using physical lattices together with either sunlight, halogen or LEDs. For the definition of surface texture, daylight and artificial spot-based light sources are preferred, due to their ability to accentuate the level of roughness and/or smoothness of the surface, covering the whole body, not only sections of the surface.

Dissemination of my experiments will -independent of media- only convey a reduced cognitive and perceptual experience for the reader. I stress the phrase 'reader', because this person is no longer a first-person observer.

Light can be considered both as material and means, but also as a methodological approach for understanding form, because a full outcome of these light experiments - in terms of a three-dimensional perceptual experience - is only possible through live observation as method. In my view, this study support the idea that light constitutes the most crucial prerequisite for creating aesthetic manifestation during the creative product design process.

6 Discussions and future work

This line of laboratory work is very resource- and time-consuming. The number of possible constellation combinations are virtually limitless; I have only been able to carry out a fraction of the potential experiments displayed in the matrix.

All my experiments staging a relative movement between light source and object have followed the principle that the light sources have been static, while the object has been rotating. I see that the aspect of relative movement should be investigated further – especially using a laser in combination with spot-clouds. An emerging assumption is that when doing the opposite, by putting the light source into movement and having a static object, this constellation could bring forth a new and valuable contribution to the visual perception of 3D form.

I regard my matrix that combines model completion levels and light sources as a framework for further studies in light experiments, as it constitute a considerable potential for exploration. Finally, I hope that my work so far and the structure of the matrix may inspire and enable other educators, design students and designers to explore light as a phenomenon and creative resource aiming at pedagogies stimulating aesthetic sensitivity.

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Manual labour and industry: a mutual stimulation proven in an intercultural research project

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The project MANUAL LABOUR AND INDUSTRY deals with the production of yarns from the fibres of fruit banana pseudo stems. These stems accumulate on plantation fields in large quantities after the harvest of the bananas. Until now, this biological residue usually ends up in waste dumps or is burned. Instead of considering these pseudo stems as waste, they should be given added value through textile processes and made available for the textile design sector. The aim of this project is to mechanically or manually produce high-quality yarns which can be used to produce woven or knitted textile samples for the clothing and interior sector as well as for composites. The project is thus characterized by an innovative approach which considers the long-established opposition between manual and mechanical yarn production as mutually stimulating. While the analysis of existing spinning processes informs the way we envisage the production of yarn from banana pseudo stems, the findings gained during manual yarn production in turn shed light on how mechanical processes could be organized and are used to adapt them. In addition, this yarn-oriented research already contains first results in the textile design sector, in which both industrially and crafted textiles were developed.

Keywords: Banana fibres; sustainability and textiles; processability of natural fibres; added value; interdisciplinarity

1 Added value out of a waste product: Banana fibres

Every banana plant produces just one bunch of bananas and is then cut in order to leave place for a new banana plant. Banana plants have rhizomes from where the new generation of plants grows. After the harvest of the bananas the cut pseudo stems accumulate on the fields. They are mostly thrown away or burned. Fibres from the banana fruit plant, more specifically from the pseudo stem, can be mechanically extracted with a raspador, a machine with rotating blades. A three-year research project conducted by the Navsari Agricultural University explored the different applications and products which can be gained from the pseudo stems (Chirag et. al. 2016). Researchers did not only extract fibres from the sheaths of the outer layer of the stem, but used the sap as fertilizer, made cardboard or paper and produced candies and juice from the inner core of the stem. When introduced to the fibres four years ago, our research group decided to carry out a research project with two partner universities in order to produce banana yarn for apparel, interiors and composites. We are convinced that new sources of fibres must be found to meet the demand for

sustainable material since the cotton production area is limited. We consider new natural fibres as the sustainable path to be explored.

Figure 1. Pseudo stems after the harvest of the banana fruit. Source: Lucerne School of Art and Design.

Figure 2. Pseudo stem with sheaths. Source: Lucerne School of Art and Design.

2 The potential of natural fibres

Since the Second World War the amount of natural fibres has gradually diminished in favor of synthetically produced manmade fibres. The main reasons for this decrease are price and the fact that manmade fibres can be transformed into any shape and guarantee a consistent quality.

However, according to the Food and Agriculture Organization of the United Nations (FAO), farmers earn millions of tons of natural fibres from animals and plants worldwide: wool and animal hair, fibres from seeds, stalks, leaves and shells, e. g. cotton, linen, hemp, sisal, and coir. From these fibres ropes or yarns and twines for woven or knitted fabrics can be made. Natural fibres still play a fundamental role in today's life.

2009 was proclaimed as the year of natural fibres by the FAO. The aim was to raise awareness amongst consumers, the industry and producers regarding the importance of natural fibres, as they provide important livelihoods for millions of people around the world.

Especially small-scale farmers are challenged with the fact that natural fibres are often replaced by synthetic fibres.

The FAO underlined the importance of natural fibres with five propositions:

1. Due to their structure natural fibres are breathable, which makes them very skin-friendly.
2. Natural fibres are important to the economies of many developing countries because they provide a crucial economic livelihood for millions of people.
3. Natural fibres are a renewable resource which is 100% biodegradable. Therefore, the FAO ascribes them a crucial role in the emerging “green” economy. Plants from which fibres are extracted absorb carbon dioxide during growth. They produce mainly organic waste during processing and leave biological residues.
4. Natural fibres are used in the building sector for insulating, reinforcing or acoustic properties. Their mechanical strength and low weight make them interesting for molded parts in technical applications.
5. Even the fashion sector is looking for alternatives for the production of “clean” clothes.

The following challenges arose during our project:

In 2017 the global world fibre market amounted to a total of 103.4 million tons (The fibre year, 2018). The largest share is accounted for by oil-based fibres with 64.9 million tons (62.76%). The still most widespread natural fibre is cotton with 25.7 million tons (24.85%). Cellulose-based regenerated fibres come to 6.6 million tons (6.38%). All other natural fibres are distributed over the remainder of 5.8 million tons (6.01%) (Müssig, 2010). In view of these figures, the leverage effect and the importance of banana fibres must be located in a niche market.

Matters were complicated further by the fact that the pseudo stems accumulate in India. Due to temporarily difficult communication with our partners in India, we limited our research activities to Europe. The aim was to demonstrate the feasibility and to convince the Indian partners that the value added in India makes sense and thus creates good opportunities for the farmers and the spinning mills.

Socially and economically we depend on the willingness to use a new fibre and to build trust in it. There are also weak points in the methods, because all tests are carried out on well-maintained machines in Europe - this would have to be transferred to the conditions of countries where the banana production is located.

It is known that insecticides, herbicides and pesticides are used for the cultivation of bananas in monocultures, particularly in countries where bananas are grown for export. In order to obtain organically grown fibres for our experiments, we cooperated with an Indian University, which provided the banana fibres for the trials in Switzerland and Europe.

3 Social relevance

Beside food, drinking water and a safe environment, textile materials are a fundamental need of mankind. Due to the growth of population the demand for textiles increases. At the same time, the available cultivation area for cotton is limited and competes with that for food production. In addition, the raw oil for the production of synthetic fibres is finite. Therefore, new resources for textile fibres must be explored. They should be sustainable and allow

long-term use without negative environmental impacts. In this context, an interesting area arises for researching the banana fibres, a by-product of the banana production, whose suitability for textile fabrics and composites is assessed.

4 Collaborative Project

4.1 From manual labour to mechanization: Questions and working hypotheses

Textile designers either start with their own developments and design work using suitable yarns to create a textile surface, or they start developing texile designs later on in the textile process chain by refining existing fabrics. The techniques used are felting, weaving, knitting, warp knitting, the analog process of screen printing or the digital variant inkjet printing as well as embroidery to name the traditional textile techniques. This results in the following question:

Which product can be developed from banana fibres that can convince potential users and producers?

The fact that an Indian partner institute initiated the exploration of banana fibres showed that the processes should take place mainly in India. This presumption proved wrong, because the Indian government politically supports the jute industry and mechanically produced yarns were scarce. Therefore yarns and twines had to be produced first. This resulted in the following question:

Which mechanical processes are suitable to spin fibres extracted from fruit banana pseudo stems?

Due to the rich experience in mechanical spinning of natural fibres in Switzerland, the necessary process steps for banana fibres were assessed by precise analysis. Trying to find funding for the project, it turned out that Indian partners were not interested in investing in the development of banana fibre processes. This inevitably resulted in a third question:

Is it possible to prepare and spin banana fibres in Europe on existing machinery?

4.2 Banana - a relevant fruit

Bananas are consumed worldwide. It is difficult to give reliable figures for the total amount of bananas produced as there are many small locally grown crops that are sold in the informal and local sector and therefore are not included in the global figures. The main producers of bananas and plantains are India with an average of 29 million tons and China with 11 million tons (FAO, 2017). The figures collected in 2015 and published in 2017 show that the cultivated land area for bananas reaches 5.5 million hectares of which India features 700,000 ha. Only about one-sixth of the 113 million tons of bananas produced are traded internationally. In many countries the majority is offered on the local market as a staple food. The productivity of banana production per hectare varies from country to country and from variety to variety. The productivity of banana production from the state of Gujarat in India, from which the Grand Naine banana fibres are sourced for the research project, is 61 t/ha (Desai, 2016). There exist around 60 different banana varieties in India. In the state of Gujarat the three most cultivated banana varieties are Grand Naine, Mahalaxmi and Basarai. Banana trees bloom only once. The fruit tufts are wrapped in plastic bags to prevent pest infestation. After flowering, banana perennials are formed with bananas weighing up to 50 kg. The fruits, which reach for the sun and thus get their crooked shape, ripen after 7 to 9

months. After harvesting, the so-called pseudo stem dies. Thanks to the rhizomes, a new shoot grows next to the dead mother plant. The ratio of biowaste to banana production is estimated to be 2:1, which equates to a mass of 226 million tons worldwide. The mass of fresh pseudo stems in Gujarat is given as 60 to 80 t/ha (Desai, 2016). The biomass of the pseudo stems is either left on the field, disposed of at high cost 200-280CHF/ha (Desai, 2016) or sent to landfills. The biomass left on the fields can maintain soil moisture and provide organic material. However, this carries the risk of possible disease transmission (Universidad Politécnica de Madrid, 2016).

4.3 Banana fibres from waste biomass

From the sheaths of the pseudo stems natural fibres can be extracted. These fibres have a light yellow-white color and as natural fibres complement the limited range of the other natural fibres. The textile properties of banana fibres are similar to those of other bast fibres, e.g. jute, sisal and linen. Banana fibres can be processed on the jute spinning line with minor adjustments, which has been proven in a feasibility study but has not been followed up (Roy et al 2014). Accordingly, the results - relatively hairy and thick yarns - are of rather low quality and thus only conditionally suitable for weaving.

The fact that there were no banana yarns available on the market confronted us with a very complex matter, namely the provision of raw fibres for a mechanical spinning process in which several parties are involved and whose process steps need to be precisely coordinated. What further complicated matters was that there is no mechanized process for banana fibres yet. Although the potential of banana fibres as matrix reinforcement in paper or composites has been discussed in several scientific articles in terms of properties and mechanical or chemical processing (Vigneswaran et al., 2015; Kulkarni et al., 1993; Githinji, 2015), all these cases deal with the incorporation of short fibres into a matrix rather than the production of yarns which e.g. have to have a certain load-bearing capacity in one direction. Yet, if textiles are to be developed, the production of yarn is indispensable.

4.4 Interdisciplinary collaboration and intercultural teamwork

The project had to take into account not only the design and engineering of products, namely the production of yarns for the defined applications - according to Buchanan the second order of design -, but also the design of systems, processes and sequences of activities and the interaction of the various stakeholders, the so-called fourth order of design (Buchanan, 2001).

After researching the state-of-the-art the hypothesis was formulated that it should be possible to spin banana fibres on the world’s existing mechanical spinning plants for natural fibres in order to initiate a textile value chain. It should be borne in mind that some existing plants are very outdated and that the slightly different properties of banana fibres have to be taken into account in order to spin them. This requires a great willingness on the part of the owners of these plants to adapt them to banana fibres.

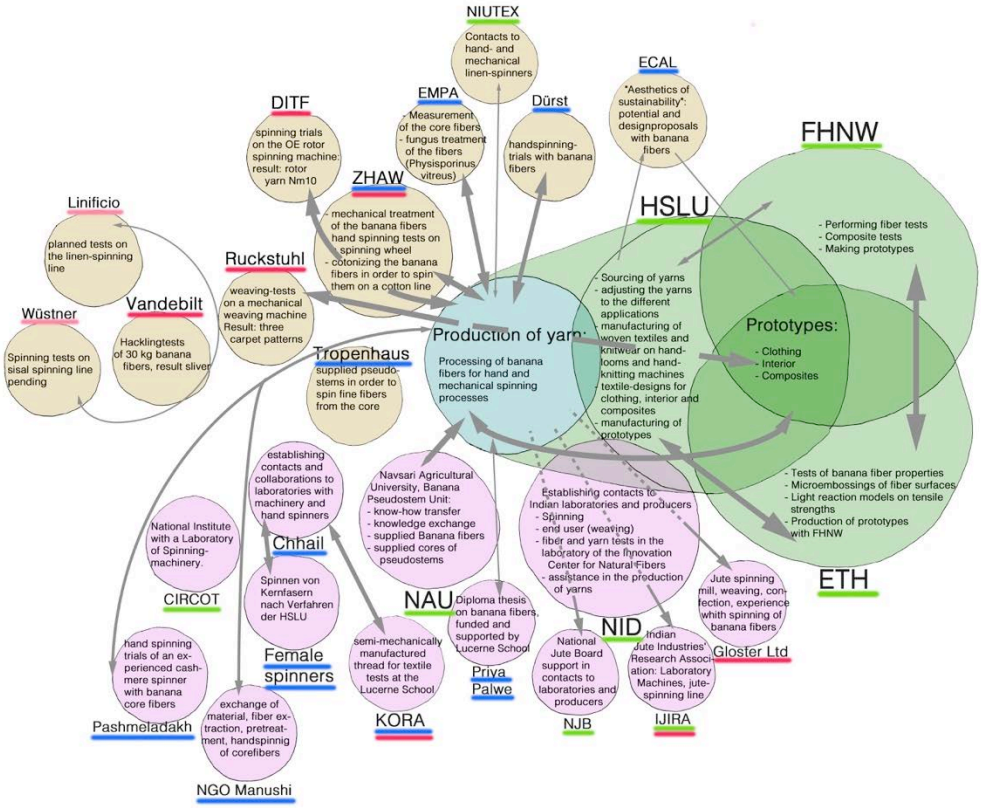


Figure 3. Graphic representation of the protagonists in the project, which show clearly the intercultural dimension. Source: Lucerne School of Art and Design.

- Blue circle in the center of the chart:
  represents the main topic of this project: the yarn production from banana fibres. It took place in a complex structure of institutions, companies, workers as well as hand and mechanical processes.
- Green oval:
  The yarn development was part of the research work of Lucerne School of Art and Design (HSLU – D&K)
- Two green circles:
  Lucerne School of Art and Design researched with the two institutions University of Applied Sciences and Arts Northwestern Switzerland (FHNW) and the ETH Zurich. The three institutions HSLU, FHNW and ETH were financially supported by the Gebert Rüf Foundation.
- Dark green intersection triangular field:
  The topic of these three institutions was the production of prototypes in order to gain interested implementing companies and further research funding.
- Light brown circles (Europe) and pink circles (Asia):
  Numerous European as well as Indian and Nepalese institutions, NGO, companies, persons and processes were involved in the research work.
- The grey arrows
  mark the mutual relationship of the respective research partners, sometimes the relations were balanced, sometimes rather one-sided.
- The blue underlines
  represent all handmade undertakings.

- The red underlines
  are the mechanical tests and processes.
- The green underlines
  are institutions and laboratories that took on a rather theoretical-intellectual or mediating role in the project.

The comparison of the methods and the results of the handmade experiments in the different countries with various approaches (Nepal, India, Switzerland) were very informative for the progress in the project. Only by understanding the craft processes and results, which have the advantage that a good result can be achieved even with small quantities, the further experiments could be planned in an industrial context and scale.

5 Fibre properties

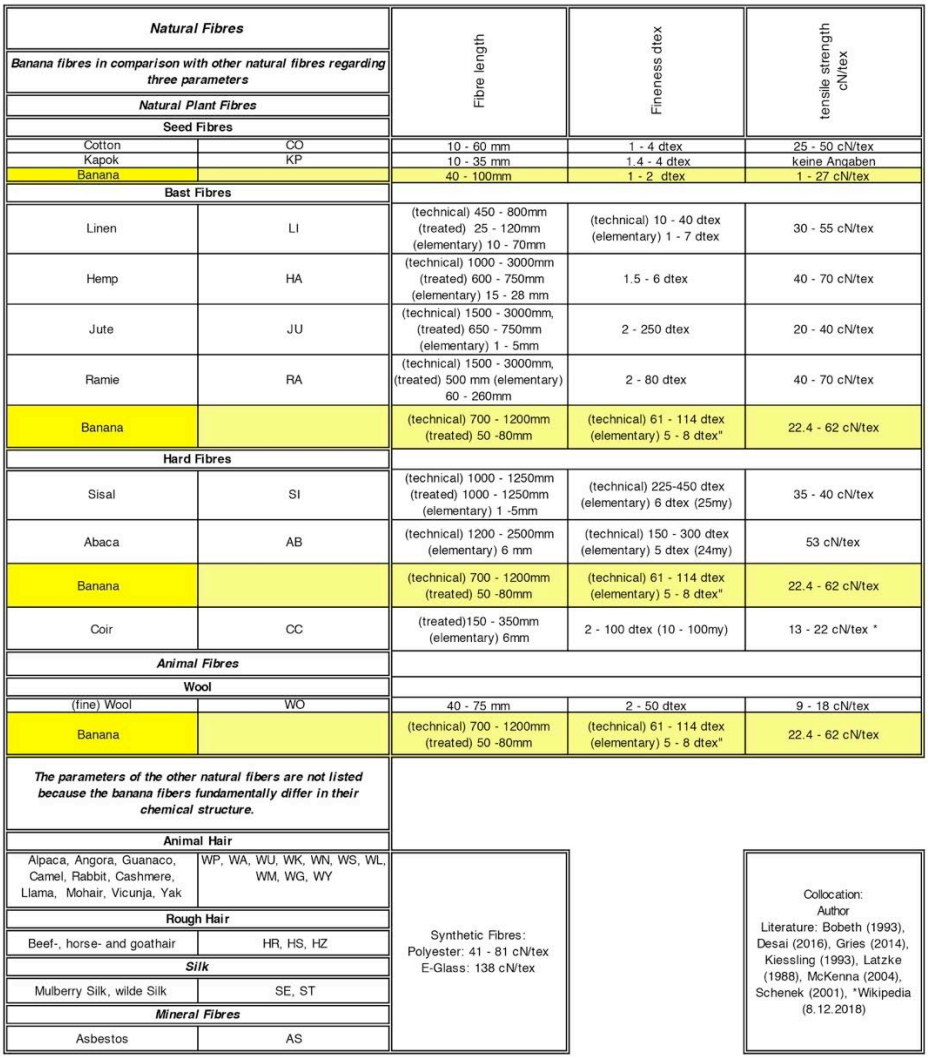
5.1 Criteria for spinnability

Natural plant fibres consist mainly of polymers with the following components: cellulose, hemicellulose, lignins and aromatics, waxes and other lipids, ashes and water-soluble compounds. The chemistry and the structure of the fibres determine their properties, their functionality and their processability. (Bobeth, 1993. Muessig, 2010). The different characteristics of fibres that can be distinguished are fibre length, fibre diameter, strength, chemical composition, extraction of fibres, processing, application. The structure of the fibres has an influence on their tensile strength. The tensile strength is the tensile force required to tear fibres, yarns or fabrics (Schenek, 2001). This force is given in cN/tex. One cN corresponds to the weight force of one gram. The applied force in cN is expressed per tex. Uniform fineness, length and tensile strength are the decisive parameters for assessing the suitability for a textile application. These parameters determine whether a fibre is spinnable to make a sufficiently strong yarn or twine in order to produce a woven or knitted fabric.

5.2 Banana fibres in comparison with similar natural fibres

The table below shows the fibres which are suitable for textile purposes. This means that the fibres are long enough to be spun into a yarn. The table lists the properties of the fibres that are relevant for spinning processes and are compared with those of the banana fibres. The banana fibres of the leaf sheaths of the pseudo stem rank among the bast or hard fibres. Bast fibres are fibres that occur either in the leaf, in the stalk or in the shell. The fibres must first be removed from the plant matrix by mechanical, enzymatic or chemical operations before they are available as fibres and can be spun in further processing steps.

The finer fibres from the core of the pseudo stem can be assigned to the seed fibres because of their fineness, even if they do not originate from seeds. Since banana fibres can be classified as seed, bast or hard fibres due to their properties, and since there is no specific mechanical spinning process for banana fibres, the spinning processes of similar fibres are shown. Afterwards, the process steps in the preparation and processing of the banana fibres are analyzed, which should provide indications for the adaptation of the existing processes.



Natural Fibres		Fibre length	Fineness dtex	tensile strength cN/tex
Banana fibres in comparison with other natural fibres regarding three parameters				
Natural Plant Fibres				
Seed Fibres				
Cotton	CO	10 - 60 mm	1 - 4 dtex	25 - 50 cN/tex
Kapok	KP	10 - 35 mm	1.4 - 4 dtex	keine Angaben
Banana		40 - 100mm	1 - 2 dtex	1 - 27 cN/tex
Bast Fibres				
Linen	LI	(technical) 450 - 800mm (treated) 25 - 120mm (elementary) 10 - 70mm	(technical) 10 - 40 dtex (elementary) 1 - 7 dtex	30 - 55 cN/tex
Hemp	HA	(technical) 1000 - 3000mm (treated) 600 - 750mm (elementary) 15 - 28 mm	1.5 - 6 dtex	40 - 70 cN/tex
Jute	JU	(technical) 1500 - 3000mm, (treated) 650 - 750mm (elementary) 1 - 5mm	2 - 250 dtex	20 - 40 cN/tex
Ramie	RA	(technical) 1500 - 3000mm, (treated) 500 mm (elementary) 60 - 260mm	2 - 80 dtex	40 - 70 cN/tex
Banana		(technical) 700 - 1200mm (treated) 50 -80mm	(technical) 61 - 114 dtex (elementary) 5 - 8 dtex"	22.4 - 62 cN/tex
Hard Fibres				
Sisal	SI	(technical) 1000 - 1250mm (treated) 1000 - 1250mm (elementary) 1 -5mm	(technical) 225-450 dtex (elementary) 6 dtex (25my)	35 - 40 cN/tex
Abaca	AB	(technical) 1200 - 2500mm (elementary) 6 mm	(technical) 150 - 300 dtex (elementary) 5 dtex (24my)	53 cN/tex
Banana		(technical) 700 - 1200mm (treated) 50 -80mm	(technical) 61 - 114 dtex (elementary) 5 - 8 dtex"	22.4 - 62 cN/tex
Coir	CC	(treated)150 - 350mm (elementary) 6mm	2 - 100 dtex (10 - 100my)	13 - 22 cN/tex *
Animal Fibres				
Wool				
(fine) Wool	WO	40 - 75 mm	2 - 50 dtex	9 - 18 cN/tex
Banana		(technical) 700 - 1200mm (treated) 50 -80mm	(technical) 61 - 114 dtex (elementary) 5 - 8 dtex"	22.4 - 62 cN/tex
The parameters of the other natural fibers are not listed because the banana fibers fundamentally differ in their chemical structure.				
Animal Hair				
Alpaca, Angora, Guanaco, Camel, Rabbit, Cashmere, Llama, Mohair, Vicunja, Yak	WP, WA, WU, WK, WN, WS, WL, WM, WG, WY	Synthetic Fibres: Polyester: 41 - 81 cN/tex E-Glass: 138 cN/tex		Collocation: Author Literature: Bobeth (1993), Desai (2016), Gries (2014), Kiessling (1993), Latzke (1988), McKenna (2004), Schenek (2001), *Wikipedia (8.12.2018)
Rough Hair				
Beef-, horse- and goathair	HR, HS, HZ			
Silk				
Mulberry Silk, wilde Silk	SE, ST			
Mineral Fibres				
Asbestos	AS			

Figure 4. Table of natural fibres. Source: Lucerne School of Art and Design.

6 Spinning natural fibres: established mechanical process chains

There exist different spinning processes depending on the fibres and the fineness to be achieved:

- The ring spinning process produces fine, uniform yarns. It requires a careful pre-treatment of the staple fibres to obtain a pre-stretched card sliver from which a roving is produced, which is drawn and firmly twisted on the ring spinning machine.
- The rotor spinning process is possible even without making a roving. This kind of spinning is faster than ring spinning, but the fibres are less parallel than in ring spun yarns. It is not possible to spin yarns as fine and strong as in ring spinning.
- Flax spinning differs in the preparation of the card slivers and in the actual spinning process. Since the bast fibres still have pectins (vegetable glue), the so-called wet spinning process is used. The pectins between the fibres soften thanks to the humidity, can thus be warped better against each other and be spun into finer yarns.

The following table shows the individual steps of the process chains of natural fibres from plant to yarn for the categories of seed, bast and hard fibres. The choice was determined by the attempt to card the banana fibres - for which there is no industrial-mechanical process so far -, using the methods of similar fibres in order to integrate them into the process.

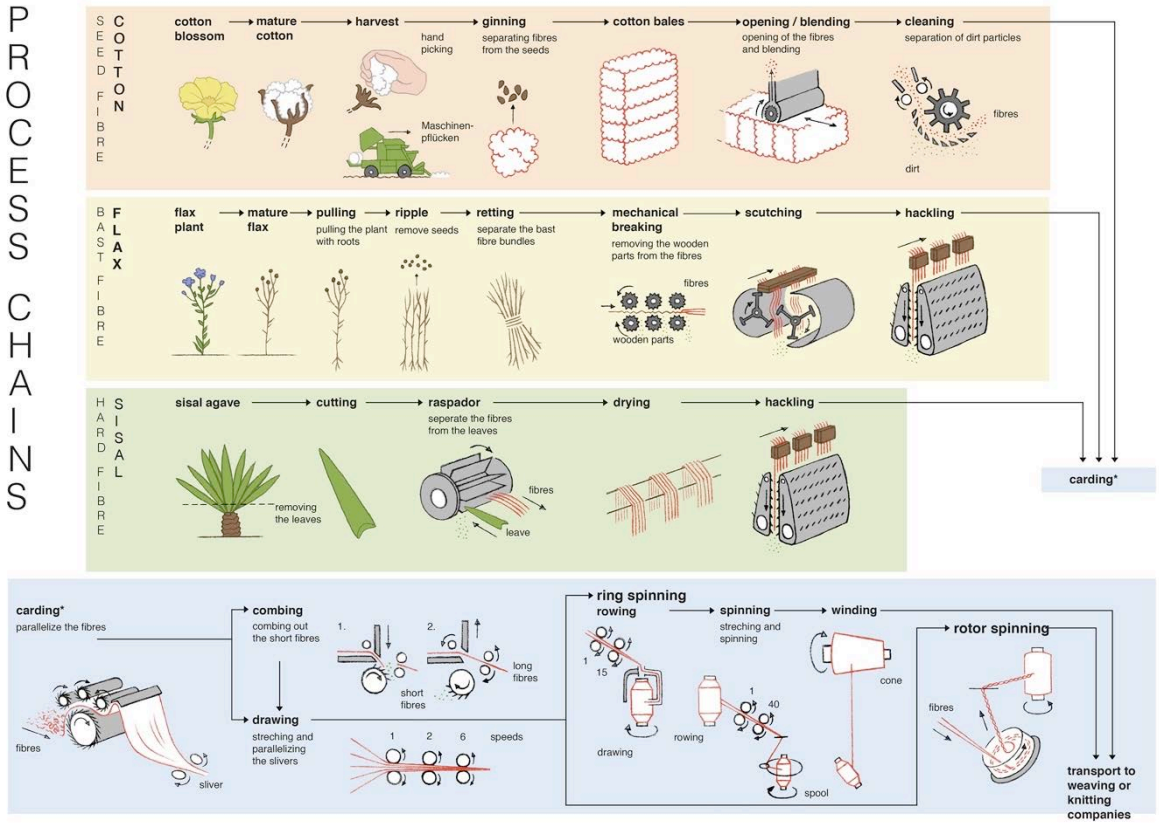


Figure 5. Table of mechanical spinning processes. Source: Lucerne School of Art and Design, Natalie Neff.

7 Description of the experiments

The individual steps used with the selected seed, bast and hard fibres described above demonstrate the similarity of the different processes. However, the fibre length and fibre fineness determine the size of the machines and the individual components that open up and parallelize the fibres. All of these preparations for the spinning processes were carefully analyzed and evaluated for suitability regarding the banana fibres. The analysis showed that the banana fibres can be treated in the same or a similar manner as the fibres discussed, thus incorporating them into these processes for spinning trials.

7.1 Treatment of banana fibres to integrate them into existing process chains

As our goal was to use existing industrial spinning methods to produce yarn from Banana fibres, we focused on the relevant process chains. Accordingly, experts were consulted to assist with the preparation of the banana fibres and the adaption of the spinning processes. The following diagram shows the process chain of banana fibres from field to prototype.

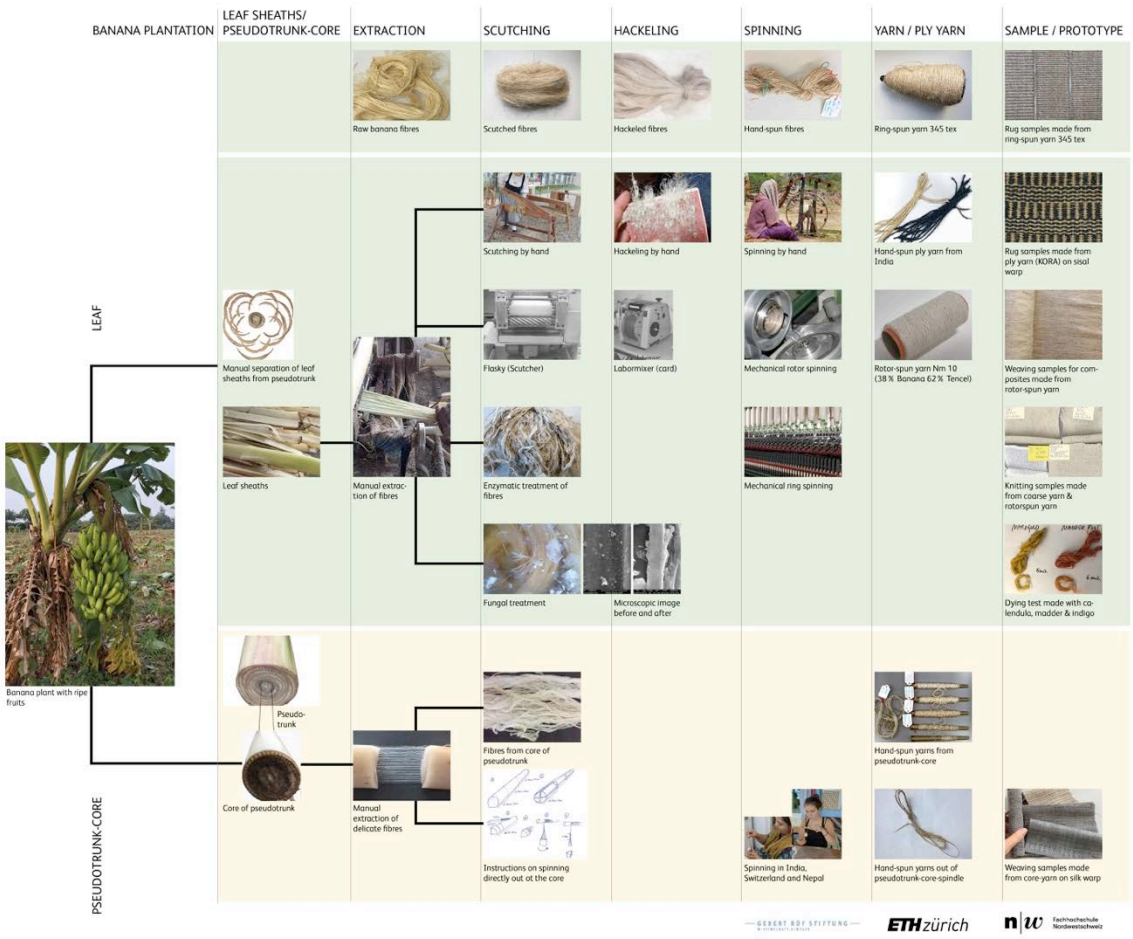


Figure 6. Table of the experiments made in analogy of existing marketable natural fibre process chains applied to banana fibres. Source: Lucerne School of Art and Design.

7.2 Spinning on the jute line and degumming

Spinning on the jute line in India is described in several publications (Desai, 2016; Roy, 2014). Unfortunately, it was not possible to encourage neither national institutes nor companies in India to develop a refined process for the banana fibres in order to obtain thinner yarns. One reason might have been that the Ministry of Textile supports the jute industry and thus discontinued research funding in the banana fibre sector. Yet, we were able to procure two kilograms of a 345 tex yarn from an Indian agricultural university which were produced during research work. With this yarn sample the following experiment was conducted by a partner university which specializes in wet stockage, pretreatment and processability of hemp fibres. The yarn was degummed using a hemp degumming process, in which the yarn is degummed in a chemical solution for half an hour at 123 ° C in the autoclave, then neutralized with hot water and acetic acid dissolved in deionized water and finally dried.

Result: The degumming made the yarn lighter, softer and fluffier. The sample lost 26.5% in weight and therefore reaches a titer of 253 tex.

Conclusion: As the yarn is still quite thick, it is better to do the degumming before the spinning process.

7.3 Weaving tests with the 345 tex banana yarn on a mechanical weaving machine

Since the 345 tex banana yarn is similar to sisal, existing sisal weave patterns were selected and adjusted to banana yarn.

Result: A weaving company wove three carpet patterns, which are usually made with sisal and coconut for their in-house collection.

Conclusion: The weaving test worked, the qualities are comparable to those of the rugs in the company's collection. Better results could be achieved with harder spun or twisted yarns. The price of the yarn per kilo would have to be around 8 CHF in order to compete with Sisal.

Figure 7. Banana yarn 345 tex. Source: Lucerne School of Art and Design.

Figure 8. Carpet samples from a mechanical weaving machine. Source: Lucerne School of Art and Design.

7.4 Hand spinning tests

In order to find out how the banana fibres would behave on a mechanical linen spinning machine, an experienced Swiss linen spinner and weaver made various experiments. First, she prepared three samples of banana fibres for spinning. One sample was left raw, one was treated with a commercial washing agent and one with a bleaching agent. The three samples were then divided and mechanically processed on the flax brake and on the hackle. Some portions were softened with a gel of boiled linseed, followed by wet and dry spinning on the hand spinning wheel.

Result: Seven different yarns were thus created, each with a description and an evaluation of the processes used.

Conclusion: The following assessment of the seven yarn samples showed that adequate pretreatment should make spinning on the mechanical linen spinning line possible.

Figure 9. Handspun yarn from banana fibres. Source: Lucerne School of Art and Design.

7.5 Mechanical treatment and cottonizing of banana fibres

Several mechanical tests on laboratory machines (a squeegee with a grooved surface and a card) were made in order to dissolve the glue between the fibres. The fibres then underwent a chemical and enzymatic process similar to the procedure used for hemp fibres. A total of twelve experiments was carried out twice. There were four arrangements, each with two different chemical and enzymatic degumming solutions.

Result: There were 24 portions of degummed fibres.

Conclusion: Using the hemp procedure for degumming banana fibres should be viewed critically because the elementary fibres in sizes of up to 5.5 mm are lost during this process (Müssig, 2010). This raises the question of how the degumming conditions can be adapted so that only the technical fibres are dissolved without dissolving and losing the fine elementary fibres at the same time.

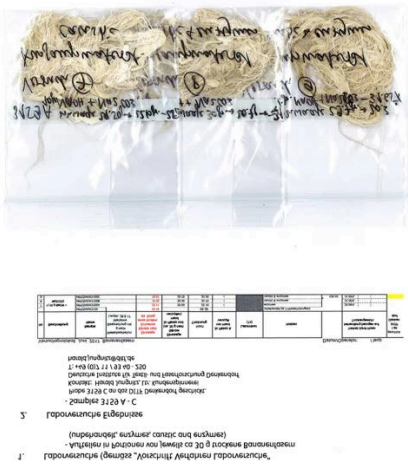


Figure 10. Protocol of degumming process. Source: Lucerne School of Art and Design.

Figure 11. Degummed fibres. Source: Lucerne School of Art and Design.

7.6 Spinning the cottonized fibres on an OE rotor spinning machine

The customer spinning mill of the German Institute for Textile and Fibre Research (DITF) tried to spin the degummed fibres as thin as possible. Spinning tests were carried out with 100%, 50% and 38% degummed banana fibres.

Result: A Nm10 yarn was produced. The ratio of banana fibres to the added tencel fibres is 32: 68. Compared to a pure Nm10 tencel yarn, the mixed yarn is less tear resistant. It also shows some unevenness from the banana fibres.

Conclusion: The degumming is one way in order to get a fine yarn. On a lab scale, it is costly to produce the blended yarn with the degummed banana fibres. The yarn is used for weaving a sample in order to test its suitability for composites.

Figure 12. OE rotor yarn, Nm 10. Source: Lucerne School of Art and Design.

7.7 Hackling of banana fibres

A Dutch linen hackling company was very open to experiments and hackled several hundred grams of banana fibres. The result was so good that a part was sent to a linen spinning mill

in Italy to check whether the mechanically parallelized banana fibres could be spun. After a positive answer, the Dutch company agreed to prepare another 30kg of the banana fibres into a sliver.

Since the banana fibres extracted from the fresh leaf shafts dry on clotheslines in India, all bundles had to be unfolded by hand before they could be transported to the hackling machine.

Result: Since the fibres are coarser than the linen fibres, they sometimes get stuck in the machine and have to be loosened by hand.

Conclusion: It is possible to break the fibres mechanically, but a mechanical pre-treatment is required, which removes the coarsest impurities and makes the fibres softer and more pliable for the hackling machine.

Figure 13. Sliver after the hackling. Source: Lucerne School of Art and Design.

7.8 Fungal treatment of banana fibres

Some meters of the banana sliver have been subjected to a fungal treatment which is normally used for the treatment of wood (Schwarze, 2011). As the surface of the banana fibres is smooth, the fibres do not adhere well to each other when spun. The fungus treatment removes the glue between the fibres and roughens their surface. This results in a refined haptic and better spinning results.

The duration of the fungal treatment was 4, 6, 10 and 12 weeks for the four portions.

Result: The surfaces of the banana fibres were modified by the enzymes released by the fungus Physisporinu vitreus. A clear structuring is visible on the surface after the treatment.

Conclusion: The results from the experiments are promising and should be followed up.

7.9 Sampling: Weaving and knitting of banana yarns

7.9.1 Carpet samples

Fabric tests for carpets were carried out on a hand loom in India. The warp was made of sisal, the weft of banana twine.

Result: The carpet patterns are woven in such a way that the sisal warp only supports the banana yarns and only the banana yarns are visible on the surface. These are very stable carpet patterns that could replace sisal carpets.

Conclusion: Coarse yarns or twisted yarns are very suitable for carpets.

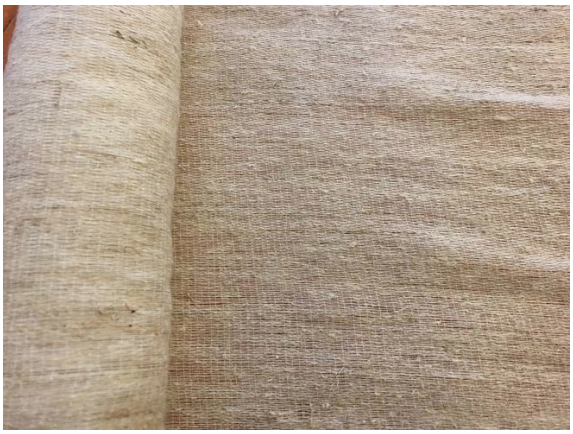
Figure 14. Three carpet patterns with banana twine. Source: Lucerne School of Art and Design.

7.9.2 Woven textiles for composites

With the Nm 10 rotor yarn (38% banana, 62% Tencel) a reinforcement fabric for bio composites was woven. The warp setting was taken from a linen textile, which is normally used for the purpose and which we wanted to replace.

Result: The fabrics for the composites are very similar to the original linen patterns.

Conclusion: Compared to linen yarns, the rotor yarn is less tear-resistant and can be used for composites that do not have to withstand high tensile and compressive loads.



Figures 15. Textile samples with rotor yarn Nm 10 (38% banana, 62% Tencel). Source: Lucerne School of Art and Design.

7.9.3 Knitted samples

Various knitting tests were carried out on a hand knitting machine with a pitch of 5. The yarn is almost too fine, so that tests were carried out with two or three yarns knitted together. A reference pattern was knitted with pure Tencel yarn.

Result: Knitting produces soft textiles. Compared to the reference pattern made of pure Tencel, the surface of the mixed yarn patterns is more irregular and livelier.

Conclusion: The yarns are suitable for knitted fabrics that could be used in the clothing sector because they are soft to the touch and can be dyed very well.

Figure 16. Knitted patterns with rotor yarn Nm 10. Source: Lucerne School of Art and Design.

7.10 The fine banana fibres from the core

Very fine fibres are embedded in the core of the pseudo stems, which can be removed. These fibres were spun by hand. Since the fibres are extracted from the wet trunk, they are glued together by the banana sap which makes them difficult to spin. Hence, they had to be moistened before spinning. Since the fine fibres also have a smooth surface and therefore adhere poorly to each other, ramie fibres were added as carriers, which results in a firmer yarn.

Result: The spinning of the pure banana fibres mixed with ramie yielded viable yarns and twines that are reminiscent of bourette silk or lotus yarn.

Conclusion: Extracting the banana fibres and subsequently spinning them are very time-consuming processes which can hardly be mechanized. This therefore remains a niche product.

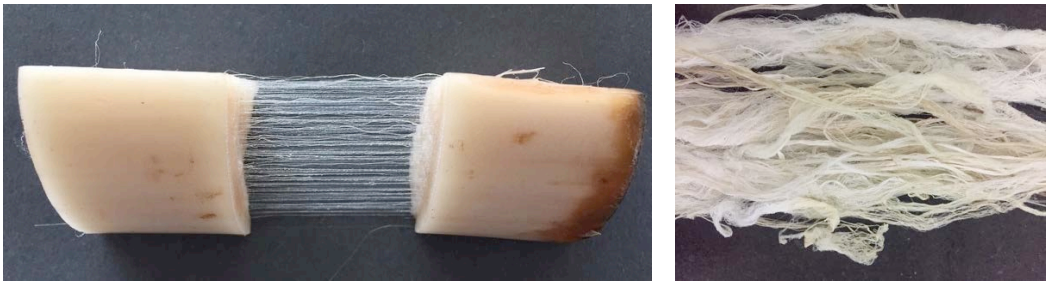


Figure 17. Images side by side showing the core of the pseudo stem with fine fibres and extracted fibres. Source: Lucerne School of Art and Design.

7.11 Development of a manual spinning process directly from the core

Since it is very time-consuming to first extract the fine banana fibres and only then spin them, a process has been developed to make spinning directly from the core possible. In order to find out whether spinning can also be done by other people according to our precise specifications, instructions were written down and the process filmed. Women in Switzerland, India and Nepal tried to spin directly from the core following these instructions.

Result: Even though this process is also complex, one can spin viable yarns from the core. Thanks to the sap, the fibres adhere very well to each other when twisted.

Conclusion: Compared to extraction and subsequent spinning, this process has greater potential. Yet, yarns obtained this way too will only have a chance as a niche product.

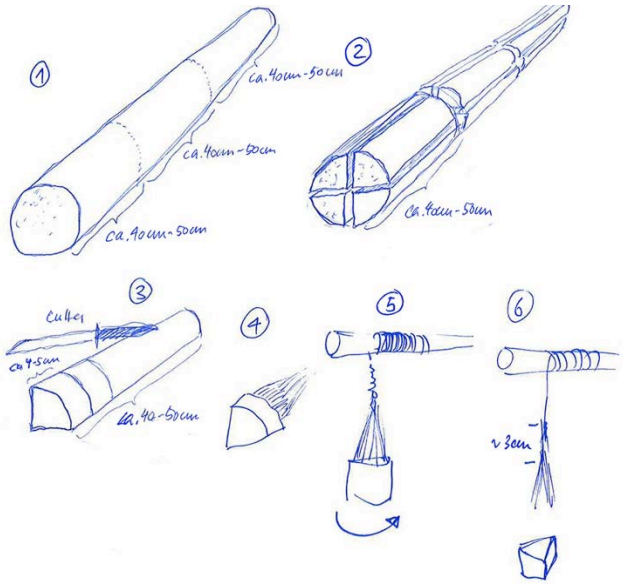


Figure 18. Procedure for direct spinning from the core. Source: Lucerne School of Art and Design.

Figure 19. Images side by side showing spinning trials with Nepalese, Indian and Swiss spinners. Source: NGO Manushi, Nepal and Lucerne School of Art and Design.

7.12 Fabric production from the yarns of the core fibres

On a silk warp several fabric patterns were created with the yarns from the core fibres. Some of the yarns were dyed to achieve a wider range of patterns.

Results: The fabric patterns are very fine, noble in appearance and feel, and suitable for use in outerwear.

Conclusion: The strength of the spun yarns is not yet sufficient for the use as warp. In order to obtain thicker yarn, the process must be adapted. It requires further research to explore the possibilities.

Figure 20. Woven samples with silk warp and banana weft. Source: Lucerne School of Art and Design.

8 The Potential: Conclusion

The research project yielded the following results:

- The coarser yarns can be used instead of other natural fibres in interior textiles. They not only possess similar characteristics, but represent a sustainable alternative since they are generated from waste. There are real opportunities for the fibres and yarns, if they are available in sufficiently large quantities and can be mechanically processed at a price that can compete with coir, sisal, fibre bananas, and linen.
- The finer yarns are suitable for composites. Their tensile strength is sufficient for molded parts that are not exposed to excessive tensile and compressive forces. Yet, they are rendered too expensive to manufacture due to the many process steps needed. In order to lower prices further optimization of the degumming and spinning processes would be necessary.
- The fine knitted and woven patterns are visually and haptically convincing and could be used in the clothing sector. The laboratory-scale effort is currently still too great to process the fibres in sufficient quantity and quality.

Thanks to the manual tests it was possible to gain profound knowledge regarding the preparation of the fibres, which could be transferred to mechanical processes. In addition to generating knowledge, the advantage of the manual tests was that the processes were disclosed in their entirety, which would have been difficult to achieve in an industrial process chain that operates globally. The application of analogies in related fields can help to find solutions to new problems.

For designers, the handwork used during the project revealed to be a well of learning opportunities. Working manually rather than with machines, enabled us to develop a feeling for the material and to gain information about the treatment, the processability and the possible adaptation to mechanical processes. Due to the small quantities of spun material it was inevitable to produce samples on hand looms or hand knitting machines, which led to further important findings about the production of textile surfaces.

The challenge remaining is to scale up the processes. In addition to banana fibres, there are many other vegetable fibres worth reassessing as shown above, e.g. linen, hemp, ramie, nettle, and bamboo. It would be advantageous if all the research into these bast fibres could be bundled and if in a joint effort an attempt were made to establish a medium-scale process chain for a quantity of approximately 30 kg spinning yarn that would be suitable for all available bast fibres. This would close another research gap, because the steps, the financial commitment and the risk of failure are large between the academic laboratory activity of a few hundred grams and the scaling to the industrial production of several hundred kilograms. Finally, I would like to state that specialization in one design field is no longer sufficient to successfully answer research questions. In order to react agilely and to focus on a sideline, it is necessary to know well all adjacent areas surrounding the specialist field.

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Proposal for an Interactive system based on sounds for leading a behaviour

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Sound influences our physical functions and behaviors. Recently, these effects are widely applied in our social lives such as in music therapy and in marketing. Furthermore, it is reported that we can predict behavior by associating the sound with a behavior. This research focuses on the behavior to 'align the shoes'. Therefore, in this research, an evaluation experiment was conducted to clarify which sound is more suitable for a new interactive system to align shoes. As a result from the experiment, we obtained two factors from seven sounds: 1) 'a sense of defeat' and 2) 'a sense of fatigue'. The interactive system was proposed based on the two typical sounds from the experiment followed by a questionnaire to clarify the impression of this system. From the survey, it was revealed that our system has positive impression such as elements of 'fun' and 'Interesting'.

Keywords: Sound; interactive; behaviour; The Fun Theory

1 Introduction

Music is widely known to have a big influence on human physical functions and behaviours (Kengo, 2006). An example of influence on human's physical functions is the behaviour of the body along with the rhythm of the sounds (Syoko et al., 2013). Another example of influences on human behaviours is that various behavioural changes may occur, such as having fun or becoming sad (Teruo, 2009).These effects are widely applied to social life such as music therapy and marketing. In addition, it has been reported that associating the sound with a behaviour can help guide following desired behaviour (Tomiei et al., 1997). Therefore, it is possible to guide a behaviour by applying music in daily life. Also, some simple actions are repeated in everyday life which might have important meanings. For example, it is a behavior to align shoes and slippers. This behavior of 'aligning' is considered to be natural behavior as a courtesy in Japan. However, the behavior of 'align' includes 'Aesthetics' and 'Functions' as after aligning, the shoes are easier to wear. It can be said that the influences of these on the relationship in-between people, people and things, people and places are very strong (Shinichi, 1984).

Therefore the aim of this study, is to propose an interactive system that guides human's behaviour elegantly, using the characteristics of sounds and the definition of The Fun Theory. In order to do that, it is necessary to conduct evaluation experiments for extracting sounds for the system. The sounds are not only to create a fun environment, but also to give a

sense of accomplishment. In addition to this research, it focuses on an interactive system that leads to the behaviour of aligning shoes.

2 Which sounds are appropriate for new system

It is necessary to conduct evaluation experiments for extracting appropriate sounds for the new system. The sounds are not only to create a fun environment, but also to give a sense of accomplishment. In this chapter, we describe an evaluation experiment to clarify whether the sounds provides people with feelings of fun and/or achievement.

2.1 The method of evaluation experiment

Since this experiment is performed using sound, relative evaluation judged that comparison of stimulation is difficult. Therefore, the experiment was conducted using the SD method (Tadahiko, 2009), which is one of the psychological measurement methods. The setup used in the evaluation using the SD method choose to graph 10 emotional variables against 5 experimental collaborators (Hitoshi, 1983).

In this experiment, using a sound as a stimulus, it is necessary to consider that the surrounding noise affects the experimental results. The subject listened to seven sounds in random order using a pair of headphones. After that, the subjects described the responses on the answer sheet based on the sounds they listened.

2.1.1 Seven sounds as stimulus

In this study, the following seven sounds were selected out from various game scenes with the five experimental collaborators. They were four successful sounds and three failure sounds, Stimulus A is the sound that flows when the aqua team and magma team win the battle in the game ‘Pokemon Ruby Sapphire’, stimulus B and C are sounds of free content, stimulus D is the sound that flows when the level of the friend rises in the game ‘Dragon Quest’, stimulus E is the sound of free content, stimulus F is the sound that flows when the game is over in the game ‘Kirby’, stimulus G is the sound that flows when the game is over in the game ‘Super Mario Bros’.

2.1.2 Implementation schedule

This experiment was conducted for 30 students of Future University Hakodate on June 13th and 14th, 2017.

2.1.3 Analysis method

The results of evaluation experiments by the SD method were analysed using factor analysis.

2.2 Experimental results and consideration

In this chapter, we describe the results and the consideration of the evaluation experiment. The result of the evaluation experiment was analysed using variance and factor analysis, and each sound stimulus was compared.

2.2.1 Results of the SD method

The results of evaluation experiments of the SD method for each sound stimulus are shown in figure 1. The seven sounds were divided into two groups: sounds of positive behaviour (A, B, C, D) and negative behaviour (E, F, G). However, although the sound of G was classed in the negative group, it was evaluated as ‘interesting.’ Furthermore, there were many sounds which were generally evaluated as ‘fun’. In addition, significant differences were confirmed by analysis of variance comparing each variables against these seven sounds.

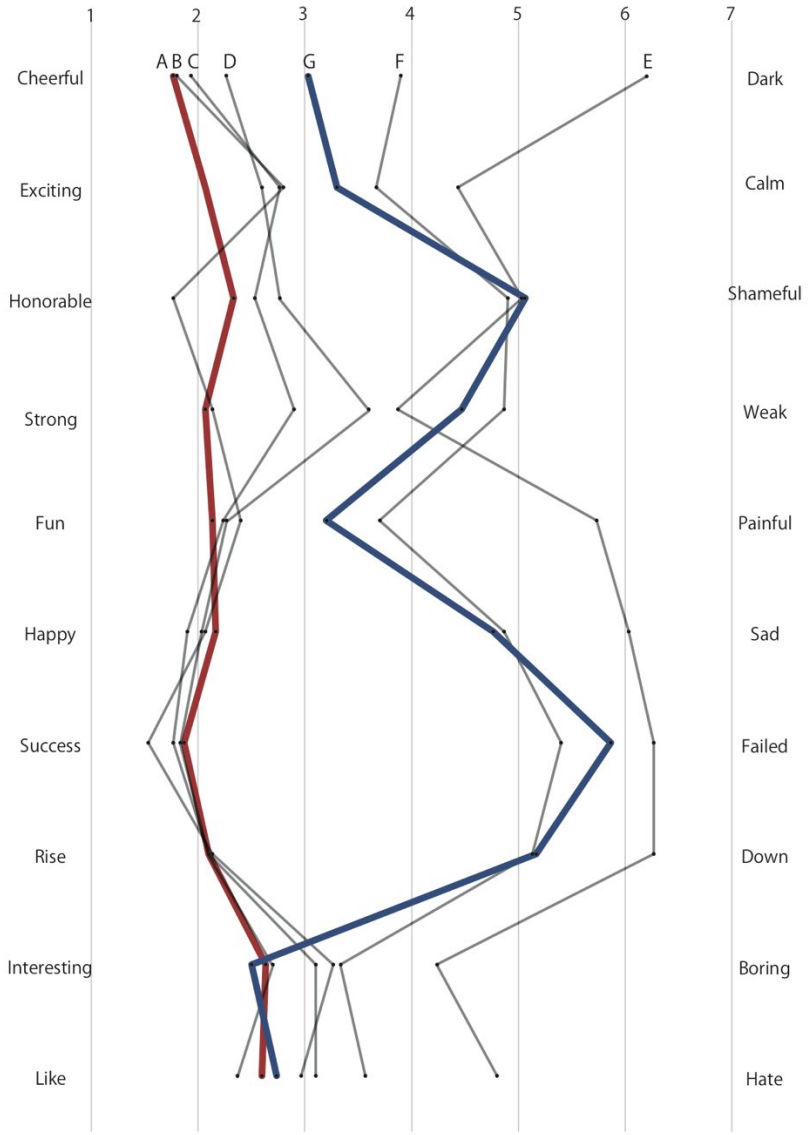

Figure 1. Results of the SD method.

2.2.2 Results of the Factor analysis

The evaluated results by SD method were analysed by factor analysis. Two factors were adopted according to the size of the initial eigenvalues and the attenuation situation. The first factor was interpreted as ‘a sense of defeat’ and the second factor as ‘a sense of fatigue’. The elements of first factor were combined with following factors: descent, shame, shady, weak, weak and dark. The elements of the second factor were painful, boring and hate.

In addition, the results that an average value that was calculated for each stimulus are shown as bar graphs for each factor in figure 2. From the graph of the first factor, the seven sounds were divided into two groups: A, B, C and D were the weak sense of defeat and, E, F and G were the strong sense of defeat. From the graph of the second factor, the seven sounds were divided into two groups: A, B, C, D and G were the weak malaise and, E and F were the strong malaise. Among them, the sound of E shown very strong malaise. Furthermore, even the same group of negative behaviours, the factor of ‘malaise’ has changed significantly. Therefore, it became clear that 2nd factor affects negative behaviour is ‘feeling of defeat’.

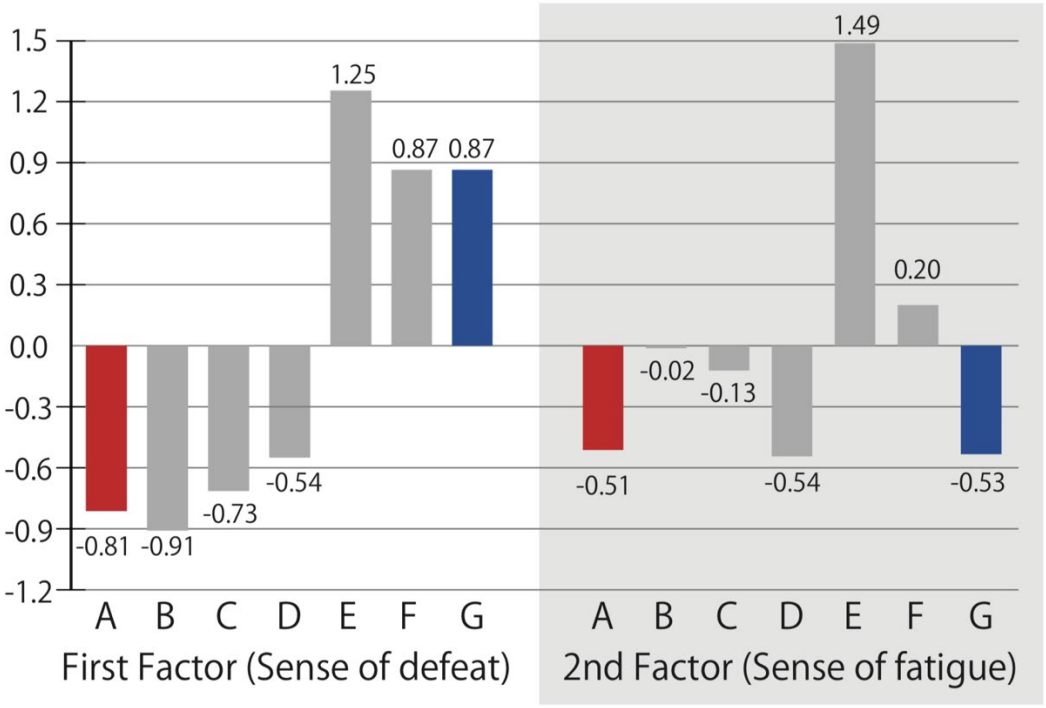

Figure 2. The table of factor score.

2.3 Discussion of results

According to factor analysis using the SD method, the seven sounds were divided into two groups: positive behaviours of the A, B, C, and D sounds and negative behaviours of the E, F, and G sounds. There was no noticeable difference between the four sounds classified to the positive behavioural group. According to these results, the most appropriate sound to 'align shoes', is the sound of A. And also the sound when it wasn't possible to 'align shoes', the sound of G was considered to be appropriate. The reasons are, the first factor's sense of defeat is high but the second factor's sense of weakness is low that is a sound that has an element of 'enjoyment' and gives a 'failed image'.

3 Proposal of the interactive system

In this chapter, It is described that this interactive system leaded to the behavior of 'align shoes' which is proposed based on the knowledge obtained by the result of the experiment and the consideration mentioned above.

3.1 Overview of the Interactive system

This system used the sound of A that flows when the aqua team and magma team win the battle in the game 'Pokemon Ruby Sapphire' and sound of G that is the sound that flows when the game is over in the game 'Super Mario Bros'. The reasons was that it tries to guide the behaviour of the person who used this system by the sound that logically extracted by the evaluation experiment. In other words, this system aims to lead the behaviour of aligning shoes.

3.2 Construction of the interactive system

The interactive system was manufactured using an Arduino UNO and four optical sensors (figure 3), (figure 4). Four optical sensors were used, one for the left toe, the other one for the left heel, and the other two for the right toe and heel . The behaviour of aligning the shoes was judged by which light sensor responded. If you aligned the shoes, this system

makes the sound of A. However, if you didn’t align the shoes, this system makes the sound of G.

Figure 3. The system which was produced 1.

Figure 3. The system which was produced 2.

4 Experiment and Questionnaire Survey

The experiment and the questionnaire survey were conducted to clarify what kind of impression the person who used the interactive system had, leading to the behaviour to align the shoes. Therefore, in this chapter, we describe the results and considerations obtained from experiments and questionnaires.

4.1 The method of evaluation experiment

In this experiment, we used SD method to measure what kind of impression the subject received from the interactive system. The various groups used in the SD method were selected in consultation with five experimental partners and pilot experiments. First, the subject listened to a brief explanation of this interactive system, confirmed the understanding of the experiment, and experienced the interactive system. The subject then took off their shoes on the interactive system and stood on the floor mat. After experiencing the interactive

system, the subject got a detailed explanation of the interactive system that the subject entered for the evaluation items listed on the questionnaire.

Figure 4. State of experiment 1.

Figure 5. State of experiment 2.

4.2 Implementation schedule

This experiment was conducted on 18 students at Future University Hakodate on December 20 and 21, 2017.

4.3 Result of the experiment

In this chapter, the analysis results of the data obtained by this experiment are described.

4.3.1 Results of the Factor analysis

The result of evaluation experiment by SD method is shown in figure 6. According to the figure 6, the general impression of the interactive system was overall positive. Among them, this system was highly evaluated for being ‘fun’ and ‘interesting’. However, in the evaluation, not much participants considered the possibility of ‘I want to use’ which was my main goal.

4.3.2 Results of the questionnaire

This section describes improvement points from the questionnaire.

Improvement points are the following: 1) It will be more fun if there are various sound patterns 2) The judgment that aligning the shoes is severe 3) I need a sign where to align the shoes 4) I don't know how to use it if I don't understand the mechanism.

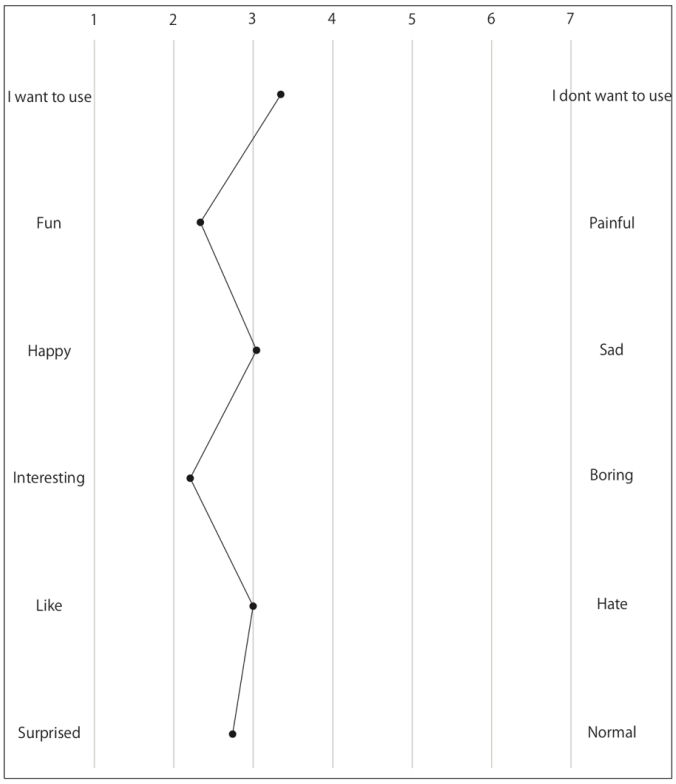

Figure 6. Results of the SD method.

4.4 Consideration

From the evaluation results of the SD method and the free-form questionnaire, we could clarify the effectiveness of the proposed interactive system. From the results of the SD method, it was evaluated that the system was 'fun' and 'interesting'. However, some subjects didn't want to continue to use it. From this, the one of purpose of this study, 'to entertain people' was achieved. This system is not sustainable. In order to use it continuously, it became clear that it was necessary to include not only the fun but also a way to make users want to use the product. From the questionnaire, it is necessary to make the mechanism of the interactive system and make a sign where to align the shoes more easy to understand. Then, we can expect that users feel to use it continuously.

Furthermore, the system's development is also expected from other examples and ideas obtained by this experiment. For example, the system is for prevention of lost article, avoiding a danger and subway.

5 Conclusion and outlook for the future of this study

5.1 Conclusions

The propose of this study is to propose an interactive system that leads human's behaviour happily, using the characteristics of sounds and the definition of The Fun Theory. In order to do that, an evaluation experiment was conducted to clarify the sounds used in the system. By the evaluation experiment, it was clarified that the subject can feel different behaviours depends on different sound stimulus. From the data obtained by the evaluation experiment, we proposed the interactive system. Our interactive system was highly evaluated for the ‘fun’ and ‘interesting’. However, in the case of ‘aligning the shoes’, it can’t be said that you want to use this system continuously. Therefore, it is necessary to maximize the value of sound while trying to use this system. And also, it is necessary to make the mechanism of the interactive system and make a sign where to align the shoes more easy to understand.

5.2 Outlook for the future of this study

In this research, as one of ‘I do not want to do even if I know that it is better to do’, this system was proposed to focus on the behavior of ‘aligning the shoes’. It can say that the sounds make us ‘fun’ and ‘interesting’. From the definition of The Fun Theory, ‘making fun’ is easy way of leading people's behaviour for the better. Therefore, this system can lead people’s behaviour. However, users didn’t say to use this system continuously. Moving forward, we aim to improve the effectiveness of this system by enhancing the value of sound while applying it to various common daily activities.

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Sujni embroidery and community practice in Bihar

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The continuance of handcrafting in India requires its existence not in a museum but in the form of living traditions. Most craftspersons who comprise a large segment of the non-farm rural economy, continue to draw from their ancestral skills and traditional, manual manufacturing modes to eke out a livelihood. In craft clusters the synergy between indigenous culture and aesthetics, material and processes, environment and way of life underpin the sustenance of livelihoods through the handmade. The craft perspective — wherein the quality of being handmade entails a significance that extends beyond the immediacy of the product and into the community of 'makers' — holds particular relevance for the study of embroidery as it combines the objectives of design and feminist studies with an embodied, experiential approach to elicit tacit, non-verbal knowledge often associated with women embroiderers. Sujni[1], the quintessential embroidery of Bihar, India has a rich heritage of aesthetics and technique, and has received the Geographical Indicator tag — a name or sign used on certain products which corresponds to a specific geographical location or origin, in 2006. The cultural connect of the community of artisans with sujni notwithstanding, this association has been largely limited to small-scale enterprises. Lack of design innovation and marketing avenues led to a crisis where the embroidery faced a downslide almost to the point of extinction. Till date, its practice continues to be fraught with challenges, most of which are encountered by the community of practice comprising women artisans who are often marginalised by gender, literacy levels and social conventions. This raises the question whether the intervention of the private sector can bring about change by offering creative and financial lifelines to the socially repressed women artisans. This paper discusses the initiatives of the private sector and schemes of the government to support the continuation of this craft. In particular, the focus is on the path breaking approach of designer Swati Kalsi to highlight sujni as textile art which, through the process of making, has empowered a small community of women artisans, tracing the journey of the humble stitch from the village environs of Bhusura village of Bihar to the Victoria and Albert Museum in London. In so doing, this paper highlights the potential of co-creation between craftspersons and the designers to reinvigorate crafts that may otherwise struggle to stay afloat and also to empower its makers.

Keywords: Sujni, artisans, women empowerment, community, fashion designer

1 Introduction

India's cultural identity has been inextricably entwined with the traditional textiles and handcrafting sector. With the socio-cultural flux resulting from the interplay of the local and the global, there is a constant imperative to balance the need to redefine aesthetics with commercial viability. Most craftspersons who comprise a large segment of the non-farm rural

economy, continue to draw from their ancestral skills and traditional, manual manufacturing modes to eke out a livelihood. Skills of handloom weaving, dyeing and embroidery as well as other indigenous techniques of production enable millions of craftspersons to make a living. An estimated 7 million upto 200 million artisans are engaged in craft production to earn livelihoods (DASRA Annual Report, 2015). India's handicraft and handloom sectors are 24300 crore (approx. USD 4.48 bn) industry contributing 10,000 crore (approx. USD 1.85 bn) to India's export earnings of 1.62 lakh crore (approx. USD 300 bn) (ibid.). Almost 10 million Indians earn more than USD 3 billion annually from handicrafts (Finger & Schuler, 2004). A few exceptions of crafts-based design houses and businesses using handmade products notwithstanding, the commercial potential of the craft sector for the artisans in India remains undefined. The fallout is that the continuing struggle of the craftsperson for sustenance of livelihood is the most important factor that is responsible for the exodus of the next generation of artisans to urban cities to search for unskilled employment opportunities. It is a conundrum that this crisis exists even though the creative economy is a highly transformative sector capable of generating employability and income generation, promoting the overall creativity of society to affirm the distinctive identity of genesis and practice of crafts, enhancing the quality of life, and strengthening human resources as the key drivers of these enterprises for empowering them to imagine their own futures and become the true wealth of nations in the 21st century (United Nations Creative Economy Report 2013). These cultural segments are essential for local businesses and can develop 'pathways that encourage creativity and innovation in the pursuit of inclusive, equitable and sustainable growth and development' (ibid). In traditional craft clusters the synergy between culture and aesthetics, material and processes, environment and way of life underpin economic sustenance for livelihood and continuance of the handmade. According to the report by All India Artisans and Craftworkers Welfare Association (AIACA) titled 'Ten Years of Craftmark: Handmade in India' the 12th Five Year Plan is estimated to have provided employment to 10.733 million persons[2] in the handloom and handicraft sectors in 2011. The Cluster Observatory Report estimates that there are around 565 handloom and 3,094 handicrafts clusters in a variety of products. Though precise statistics are unavailable, it is estimated that about 200 million people are employed in these clusters (Craft Economics and Impact Study 2011). The potential of this sector for higher growth includes its capability to act as an important resource for other sectors in terms of knowledge, skills and design (ibid.).

The craft perspective holds particular relevance for the study of embroidery as it combines the objectives of design and feminist studies with an embodied, experiential approach to elicit tacit, non-verbal knowledge often associated with women and embroidery. Sujni, the quintessential embroidery practiced in the state of Bihar exists predominantly within a craft environment where all the makers are women. A similar initiative has been taken by Indrajit De and Saumya Pande who are engaged with the initiatives of Zameen Astar Foundation for women's empowerment in the Kishanganj district of Bihar to show how the migration of the ethnic Surjapuri and the Shershabadi communities from West Bengal impacts the 'visual vocabulary and craft of quilting' (De and Pande, 2018) setting it apart from similar embroideries. Unlike most embroidery in India, the traditional aesthetic heritage and technique of sujni is a story of needlework and women. In spite of having received the Geographical Indicator tag in 2006 and included in the list of traditional crafts supported by the schemes of the Government of India, the practice of sujni is fraught with challenges, most of which are encountered by the community of practice comprising women artisans who are often marginalised by gender, literacy levels and social conventions. Jean Lave and

Etienne Wenger refer to the robust form of communities of interest that lead to sustainable learning as ‘community of practice’ comprising groups of people who share a concern or passion for something they do and learn how to do it better as they interact regularly (Lave and Wenger, 1991). This raises the question: Can the intervention of the private sector bring about a change by offering an economic lifeline to the socially marginalised rural women artisans?

2 METHODOLOGY

To address the question, this paper goes beyond the associated narratives of historicity, appearance and technique of traditional embroidery to focus on sujni, the quintessential embroidery practiced by the women in the Muzaffarpur district and some villages of Madhubani district of Bihar. It traces the socio-cultural journey of the humble sujni stitch from the village environs to the Victoria and Albert Museum in London. In particular, we highlight the case study of fashion-textile artist Swati Kalsi who engages with rural women artisans in fifteen villages of Muzaffarpur, Bihar to harness the creative possibilities of materials and techniques through design inputs to facilitate community-based embroidery practices. With the objective of studying the tripartite synergy among design professionals, community of practice and handcrafted textiles, the lived experiences of the women artisans are studied through participant observation, semi-structured interviews and a field visit in order to understand their motivations in engaging with sujni embroidery and its impact on their lives.This document is formatted using the IASDR style and formatting. All styles are preceded with ‘IASDR’ so it is easily identifiable in the Styles menu.

3 SEMIOTICS OF SUJNI

Hand embroidery and woven textiles in the handcrafting and handloom sectors respectively, are the mainstay of Indian fashion. The ‘Indian thread is something of an arterial lifeline that connects the spirit of this vast nation’ (Tewari, 2013). While sujni embroidery is believed to go back several generations, the extant sample is dated around the mid-1920s. The etymology of sujni, a Hindi word, derives from su meaning ‘propitious’ and jani meaning ‘birth’. Drawing from belief in the local deity known as Chitiriya Ma[3], sujni combines and layers fabric remnants into a larger and complete whole. It is a labour intensive method that incorporates white or coloured fabric pieces derived from a used saree and dhoti[4] that have become soft with prolonged years of wear and washes, and then quilting them together using recycled yarn from the discarded garments usually of the same colour as the base fabric. There are ‘105-210 stitches per square inch’ depending on the finesse of the work (Ranjan & Ranjan, 2008). Though the stitch repertoire is predominantly characterised by running stitches, harua[5] and sikadi[6] stitches are also used. The purpose is to make a quilted sheet or soft coverlet to swaddle the newborn infant after birth as it closely replicates the touch and aroma of the mother’s skin and is akin to enveloping the infant in a gentle maternal embrace. The base material has now given way to a thicker cotton, or a cheaper variety of white or coloured markeen (muslin) or Tussar silk. Commercial embroidery skeins are used to develop a product range that includes home products such as quilts, bed sheets, cushions as well as clothing items such as the saree and kurta[7].

Sujni is frequently compared to Kantha which is the typical and widely recognised embroidery from the neighbouring state of West Bengal which finds frequent mention in fashion and textile literature. Traditionally both sujni and kantha used the yarn unpicked

from borders of saris and used for re-embroidery on a different fabric base. However, there are some differences between the two handcrafting techniques. In both cases, the stitches include straight as well as curvilinear running lines. Another difference is that sujni embroidery often involves the outlining of motifs with chain stitch in black or dark colours while kantha motifs are outlined with running stitch.

Sujni can be differentiated from other forms of quilting practiced by women in almost all parts of India by its unique narrative elements. This has played a significant role in the international recognition received by this embroidery as evidenced in the exhibition pamphlet produced by the Asia Society in New York in 1998 on eastern Indian quilts (Gunning, 2000). The motifs are usually designed and embroidered by the women to express their emotions and experiences, transforming the simple quilt into a story of their lives. Traditional auspicious motifs express a mother's love and protective instinct for her child. Other embroidered motifs represent the daily rhythms of their everyday lives including life-giving forces of the sun as source of heat and cloud as the source of rain, fertility symbols, sacred animals believed to provide fortification against malevolent forces and to elicit divine blessings. The colour of the embroidery skeins are symbolic of nature – red represents the life force of blood, yellow denotes the sun, green represents nature, and blue is the infinity of the sky and life-giving water. Over the years, the repertoire of motifs has extended to include iconography from everyday life in rural settings, or recurring events – the transition from day to night, episodes of Hindu epics, village deities and environment. Of significance are the relatively recent development of visual representations of social messages - struggle for women's rights in a patriarchal society, angst of child marriage and female infanticide, political and domestic violence, marriage dowry for the daughter, community congregation of male villagers amidst women with veiled faces, desire for female education including daughters, lessons in healthcare and other topics of direct relevance to their lives.

4 COMMUNITY OF PRACTICE

The community of practitioners of textile crafts embody notions of traditional skills performed in familiar surroundings. The most common use of community is in relation to geography where 'community' is used as a 'label for a group of people defined by a bounded space or distinct locale, such as a neighbourhood, town or region' (DiSalvo et al. 2013:184). The geographic community alone does not necessarily constitute an internal shared sense of belongingness; it may be characterised by a 'shared imagery' or that the 'geographic construct of a community is imposed from the outside, perhaps tied to infrastructural or legislative markers such as roads or voting districts, while internal to the geographic bounding there could be a multiplicity of distinct communities identified by identity vectors and/or shared interests and practices' (Anderson 1991). One way of understanding a community is to focus on its shared interests and practices where there is an ongoing shared involvement or knowledge of the origin of craft lineage embedded in the collective experience, community memory and aesthetic conventions of the cluster (Jha & Narang 2015).

In spite of the cultural connect of the community of artisans with sujni, this association has been largely limited to small-scale enterprises. Lack of design innovation and marketing avenues led to a crisis where sujni embroidered products faced a downslide almost till the point of extinction. In 1988, it received a boost with the initiative of Adithi, a voluntary agency which has made significant contribution in the revival of sujni in association with Mahila

Vikas Sahyog Samiti (MVSS), an NGO registered as an autonomous society. MVSS coordinates sujni projects with the artisans living in Bhusura and the four nearby villages of Manipur, Baghakhal, Dhanaur and Ramnagar where there are small craft clusters spread across the surrounding areas of Hasna, Ramnagar, Durganagar, Dahiya, Kothiya, Chidaila and Jarang. It undertakes training of the sujni embroiderers, provides them with raw materials, takes orders from the indenting organisation and assigns it to the artisans. Their payments are made at fair wage rates on completion of the assignment. Nirmala Devi, Chairperson of MVSS has been instrumental in taking the initiative in promoting sujni. Approximately about 400 women from 22 villages around Bhusura are currently working on this embroidery technique. This is in consonance with the idea of neighbourhood based organisations functioning as a means of providing coherence and providing proximal opportunities for interaction' (DiSalvo et al. 2013). The sujni project has given the opportunity to disadvantaged women such as widows and women who want to send their children including the girl child to school. Evidence of the benefits of their empowerment motivates other traditional housewives restricted by social customs to step out beyond their homes to earn money which provides the opportunity to break the cycle of poverty. The profession of sujni embroidery is deemed respectable even by the male members of the family and by the in-laws. The scope for independent income is especially important for women as they experience a sense of self-confidence in being able to supplement their families' meagre income from agriculture.

Sujni embroidery received the Craftmark recognition by AIACA as well as official recognition and protection in 2006 under the GI Registration Act. Other Government schemes have also extended support for the craft. Baba Saheb Ambedkar Hastshilp Vikas Yojana is a government initiative to develop the clusters and implement through 'specialised interventions such as design development, skill upgradation, technology support, marketing and infrastructural support' (Scheme under the Office of the Development Commissioner – Handicrafts). The Marketing Support & Service Scheme of this office aims to create wider 'awareness about Indian handcrafted products through marketing events which encourage entrepreneurship and provide financial assistance to state handicrafts corporations for setting up new retail outlets' (ibid).

However, sujni faces disadvantages that do not augur well for its growth. The intricacy of the embroidery and inadequate electricity cause intense strain on the eyes while the non-ergonomic seating arrangement causes back pain. The clusters largely comprise young girls between the age of 16-20 years, many of who have worked with sujni for at least one year to subsequently marry and migrate to another village or town. The fluctuation in the numbers of the artisans is also due to discontinuation of embroidery practice by women after marriage and childbirth. While on the one hand, the idea of independent earning is attractive for women from different communities as well, there is insecurity regarding the inadequacy of the monthly income ranging from 300 -1000 rupees, delayed payments and the intermittent flow of work.

5 DESIGN INITIATIVES BY SWATI KALSI

Swati Kalsi, a graduate from the National Institute of Fashion Technology, Delhi in 2003 is a fashion and textile designer-maker-artist whose eponymous label 'Swati Kalsi' falls within the genre of wearable textile art using sujni embroidery. The experience of being one of the designers working from 2008 – 2011 at Jiyo an initiative launched by designer and cultural

preserver Rajeev Sethi's Asian Heritage Foundation under which creative grassroots enterprises are self-managed by the skilled poor, inculcated a deep-rooted concern to enable skilled but economically vulnerable communities to develop cultural livelihoods. Recognising such communities as India's most important cultural and creative resource who need to be empowered and recognised for their repository of traditional knowledge, her singular approach to sujni lies at the intersection of art and design as works of wearable art. Textile artists often strive to reach the status of 'high art' they believe the embroidery genre deserves (ibid). Kalsi's endeavour to discover a vocabulary that she could claim as her own, led to her tryst with the sujni artisans of fifteen villages of Bhusura district in the Gaighat block of Muzaffarpur in Bihar through re-interpretation of the indigenous embroidery. Her first independent collection in 2012 leveraging the potential of sujni, was reflective of her design aesthetic which was conceptual in nature and realised through the intricacies of the technique. This unique approach stemmed from an inherent understanding that in order to be ecologically sustainable, traditional knowledge needs a crucial interface to navigate its way into the vernacular of contemporary design to reposition itself in the national fashion scenario. The overarching purpose has been to create a truly swadeshi[8] brand that understands, leverages and showcases the inherent potential of sujni to create fashion of uncompromising quality that transcends geographical and cultural boundaries.

6 PARTICIPATORY DESIGN PRACTICE WITH ARTISANS

In 2012 Kalsi organised the first workshop at Delhi for the women artisans of Bhusura and other neighbouring villages. The dual thrust on design direction and new orientation to skilling formed the base for sustained endeavour. The embroidery has slow, singular, portable production that is convenient for these women. Kalsi has adopted an inclusive approach to leverage the inherent but under-rated knowledge of oral traditions and skills of the craftspersons handed down the generations. She engages in discussion with the embroiderer, sketching as she explains the specific design direction which includes the size and balance of the composition, colour, quality and direction of the stitches. An embroidery sample is developed that is indicative of her vision for each piece. The germ of the idea grows organically, guided not by a rigid khaka[9] but an indicative one that results in patterns of artistic abstraction with unusual combinations of coloured silk and metallic yarn. For Kalsi, the appeal of sujni lies in the 'design aesthetics as in the participatory process of making'[10] wherein there is scope for flexibility by the artisans to interpret her concepts. The embroidery process completely engages each maker who responds to the feel of the fabric and the nature of the yarn in their hands, improvising on the embroidery. However, the final decision on the aesthetic destination is taken by the designer. The embroidery has a distinct design vocabulary that is dense and yet eschews ostentation. It is a slow, contemplative process where the rhythm emerges from the measured and calm pace of work. The unreplicable quality of each piece draws attention to the extreme intricacy of workmanship and symbolises its 'humanness' and charm. The identity of the individual maker and the product fuse into a collective albeit in a more spontaneous manner where each piece is niche and characterised by her signature style. The layered and textured pieces are situated at the cusp of design, art and craft, have contemporary relevance. Kalsi's contemporary approach to make unique one-off pieces of textile art is instrumental in ensuring that they remain beyond the vagaries of fashion.

Figure 1. Sujni embroidery in progress. Source: Swati Kalsi

At the heart of the absorbing practice of sujni embroidery is a satisfaction that is almost therapeutic. The sujni artisans express palpable satisfaction in the creative flow where they exhibit an interesting balance of intense concentration combined with small talk indicative of their interpersonal camaraderie. The opportunity and process of embroidery are both satisfying and sustaining for them. They exhibit commitment and emotional attachment to their work indicative of their self-identity being often linked to their practice. The motivations of the women embroiderers for producing textiles that are aesthetically meaningful have strengthened over time. There is growing awareness that it is through sujni that their daughters may have the opportunity in future to overcome illiteracy and for their voices to be heard within and beyond their homes. They realise that the practice of sujni needs to continue and flourish as it is vital to their individual identity. The success of Kalsi's initiatives can be measured by the continued sustenance of limited handcrafted items using traditional sujni embroidery which in turn, continues to empower communities of women artisans engaged in its practice.

Figure 2. Swati Kalsi with sujni embroiderers. Source: Swati Kalsi

From 2012 onwards Kalsi organises annual workshops in Delhi for a fortnight to a month for 15-20 women artisans which includes facilitation of their travel, boarding and lodging. This gives them valuable exposure to skill updation. In the scenario of disenchantment and continued loss of traditional handcrafted techniques in the crafts sector, Kalsi's commitment to ethical work practices and the tenets of sustainability becomes more meaningful. The authenticity of the region and culture from which sujni emanates is duly recognised and the community of women practitioners that produce the work are duly compensated. Usually made in natural fabrics, the items include reversible jackets with altered patterns, swing

jackets, capes, palazzos, wrap skirts and sarees. The embroidery whether sparse or dense in achromatic, aquatic or jewel tones, are dense yet not overwhelming. The value of the items stems from the quality of fine workmanship that underpins the traditional techniques and the social angle. The prices of pure cotton, linen and silk items begin from 15,000 rupees (approximately £150); the more intricate pieces command higher prices starting from 1,50,000 to 300,000 rupees per piece (approx. £1500-3000). The pricing is testimony to her confidence that discerning consumers would appreciate the aesthetics and the labor-intensive process in order to justify investment in the originality and uniqueness of each handcrafted piece. Against the backdrop of history, heritage and culture, the artistic renditions and authenticity of limited editions of signature sujni pieces using traditional artisanal skills have reinvigorated the overexposed branded luxury fashion market and positioned the 'handcrafted in villages' as the new luxury. However, high costs and challenges of development and innovation pose challenges for sustainability, thereby also necessitating a diversified range with varying price points.

In 2014 she showcased a capsule collection highlighting sujni at the Summer/Resort edition of Lakme Fashion Week in Mumbai. This aesthetic quality was recognised by Lekha Poddar of the Devi Art Foundation and led to the inclusion of Swati Kalsi among the designers invited to participate at an exhibition in 2015 titled 'Fracture: Indian textiles, New conversations' featuring a diverse range of hand-made Indian contemporary textiles curated by textile aficionados and design practitioners Mayank Mansingh Kaul, Rahul Jain and Sanjay Garg. It addressed the gap resulting from the lack of museum quality masterpieces by including textiles that depart from tradition towards contemporary interpretations. Swati Kalsi's sculptural textile from the 'Fracture' show was among the curated pieces included in the 'Fabric of India' exhibition of historical and contemporary Indian textiles at the Victoria and Albert Museum, London in 2015 -16. This singular piece combined sujni with couching technique to great effect 'providing visual variation and texture' (Crill, 2015) which found appreciative resonance among a global audience.

Figure 3: Section of sujni embroidered textile at V&A museum. Photo courtesy: Swati Kalsi

In working towards creating demand that can sustain handcrafting, fashion designers have become 'the modern-day patrons' (Gale and Kaur, 2011) of the Indian crafts sector which 'is one of the last of its kind' (ibid.). Sass Brown credits Swati Kalsi with being a craft revivalist in textile innovation and bringing contemporary relevance to artisanal handcrafted textiles 'by engaging with artisans in an interactive creative process to create distinct pieces of work on the edge of design, craft and art' (Brown 2015). Sujni embroidery in traditional motifs and earthy colours is widely available and better priced. Kalsi's modern renditions while

maintaining the authenticity of technique, have reinvigorated and repositioned sujni in a new idiom which caters to a global luxury aesthetic and evokes interest among the cognoscenti and affluent buyers for bespoke pieces. In so doing, her design approach to handcrafting underscores the originality of her style as being akin to art, which has a higher value than those that are considered traditional. Kalsi's commitment to maintaining the historicity of sujni through engagement with the community of practice through contemporary design interpretation has, in turn, has brought national and global visibility to this embroidery.

7 CONCLUSION

The subject of textiles, with its concomitant processes of making, use and even disappearance, cannot be examined in isolation. It may be so deeply implicated in the lives of its makers that it has the power to influence their destinies, as well as familial and even social structures. Conjoining craft and design can enhance the value of craft tradition and recognise the contribution of the makers 'while simultaneously re-contextualising and re-valuing the artisanal work through sophisticated design' (Brown 2015). Swati Kalsi's approach to co-creation with the community of practitioners of sujni has transformed the humble, everyday sujni into an embroidery technique with finesse, thus conferring couture status to selected items of clothing. Swati Kalsi's use of sujni is significant insofar as she is the only Indian designer whose method has empowered rural women embroiderers by encouraging them to dream and aspire. Ironically, the same uniqueness that makes Swati Kalsi's work noteworthy also poses a problem. At one end, it has fostered the positive change described in this paper. On the other, it renders her approach difficult to compare to that of any other designer. Nonetheless, it could be argued that the quality of being rare holds enormous potential for researchers looking to explore innovative and collaborative solutions to issues that plague the Indian craft communities today. Kalsi exhibits exemplary conviction and patience in training the makers till they attain a degree of self-reliance. and confidence to continue to embroider. Her work underscores the need for the continuance of the handmade not in a museum but in the form of living and evolving traditions. As with other crafts, exploring the potential of sujni also requires design intervention and collaboration of stakeholders – women's organisations, craft organisations, business professionals, government and non-government organisations to create a supportive ecosystem for artisans who want their craft to evolve as well as self-sufficiency and better livelihoods for themselves. Thus, when placed at the intersection of business, craftsmanship and market access, craft traditions and the communities of practice can be sustained. Recognition, financial support and a vision for the future can energise not only the makers of sujni, but equally artisans of other handicrafts so that their skills can continue to flourish.

8 NOTES

[1] Sujni embroidery work of Bihar is protected under the Geographical Indications of Goods (Registration & Protection) Act (GI Act) 1999 of the Government of India. It was registered by the Controller General of Patents Designs and Trademarks under the title 'Sujini Embroidery Work of Bihar' and recorded under GI Application number 74, Class 26 as a textile item. The GI tag was approved on 21 September 2006

[2] Report of the Steering Committee on Handlooms and Handicrafts constituted for the Twelfth Five Year Plan (2012-2017), VSE Division, Planning Commission, Govt. of India, 2012

[3] (*trans*) 'The Lady of Tatters'

[4] Unstitched fabric draped into a bifurcated lower garment for men
[5] Filling stitch
[6] Chain stitch
[7] Indian unisex tunic
[8] From one's own country; from India
[9] Design drawn on paper prior to transference on fabric
[10] In conversation with the author

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Take Inspiration from Traditional Crafts—The Transition of Traditional Blue Calico Patterns and Its Application in Modern Interior Design

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This article aims to explore the design pathway of building modern interior space with traditional elements by transforming and applying blue calico patterns. Theoretically, this practice is based on 'skin theory', which regards clothing as a secondary skin and the enclosure of walls as the third covering; thus, textiles and interior space could be related to each other. The research explores the theory by combining the traditional textile of blue calico with interior design through conducting a theoretical analysis, a case study and design practices. Inspired by the general interior design procedure and the craft-making process, a three-phase work-flow model is developed, which consists of the initial research of the craft, the transformation of the craft's patterns and the project design for applying the transformed patterns. The initial research phase serves as evidence for the later design decision making. The transformation phase, consisting of dimensional, spatial and materialistic methods, plays a central role in coordinating traditional patterns with modern aesthetic value. Through the project design phase, the transformed patterns could be used in various interior spaces.

Keywords: Interior Design; Blue Calico; Traditional Crafts; Pattern Study

1 Introduction

In the era of globalisation, the local identity of interior design has becoming a hot topic. In such explorations, the application of traditional symbols in interior space is repeatedly practiced in China, for example, the Chinese socialist style of the 1950s and the traditional revival style of the 1980s. The Chinese socialist style of the 1950s, which utilised national symbols as the form while preserving socialist style as the content, aimed to convey national pride (Yang, 2010). This style deviated from the Soviet style, which the authoritative government had supported before the Chinese socialist style. The traditional revival style of the 1980s emerged because of the national identity worries prompted by Western styles flooding into the country through the Open Door policy (Zhang, 2009). Unlike the previous explorations that had focused on a grandiose scale for national identity, the current practices are more prone to utilise specific and detailed cultural heritage elements to represent regional feeling. However, the explorations, to a large extent, are focused on collages of

traditional decorative symbols, whereas the transformation process and the underlying design logic are ignored. This essay takes the traditional blue calico as a case study, starting with an analysis of its crafts and then discussing the design procedure through exploring the transformation of its patterns and applications.

2 Theory

In the mid-19th century, Gottfried Semper proposed four elements of architecture—the hearth, the roof, the enclosure and the mound—that corresponded to the craft-based arts of ceramics, carpentry, weaving and masonry. Enclosure was considered to be connected with weaving and the theory of ‘wearing clothes’, and the intimacy between architecture and textiles is emphasised in his book, Four Elements of Architecture. Adolf Loos developed Semper’s viewpoints in the book Decoration Laws, pointing out that the historical origin of decoration was actually a spatial maintenance structure. Semper then traced the origin of architectural motivation as suspended textiles. In 1995, Kenneth Frampton, an architectural theorist, interpreted Semper’s enclosure theory in his book by distinguishing thick walls (known as die mauer in German) from lightweight walls (called die wand in German). While both wall types provide enclosure, the latter involves the German words for ‘garment’ (gewand) and ‘modification’ (winden).

Inspired by Semper’s theory, many researchers have tried to connect space with textile and clothing to explore design possibilities for interior space. Anni Albers (1957) developed the ‘skin theory’, which regarded clothing as a secondary skin and the enclosure of walls as the third covering. Lois Weinthal (2014), inspired by Albers, noted that interiors could be seen as a series of layers that wrap and enclose the body. In her studio class at UT Austin, she then explored interior skin by applying scalar changes and material translation to transform body layers into interior skins. later on, many sholars developed skin theory with their understanding. Among them, Meg Jackson (2014) recognised the layers that surrounded us allowed for redefining what interior means. Matina Kousidi (2016) discussed the intersections and overlaps between architecture, dress and textile design.

Therefore, the following two points can be concluded: first, the building's enclosure system, with more freedom for further design, is an essential and relatively independent aspect of architecture; second, textile and clothing design has long inspired architectural and interior design. These two points could theoretically prove that a connection between blue calico and interior space can be established. Because blue calico used to play an important role in Chinese people's daily lives, it has been widely used as clothes, hoods, tablecloths, window curtains, door curtains, cushions, quilt coverings, wall coverings and other interior decorations. As a kind of flexible textile covering, blue calico has been used as everything from body covering to interior furnishing and space covering. Through covering things, blue calico has connected with different forms of skins. At this point, blue calico is related to the concept of interior layers. Additionally, scholars' exploration discussed above generally tries to draw inspiration from fashion to interior skin, ignoring the traditional textiles which contain cultural context might bring more possibilities. Evidently, blue calico is not a common textile layer; it is unique because of its typical white-and-blue colour and its symbolic patterns, which make it easily recognisable. Thus, the transformation of blue calico and its application can provide new inspiration for regional interior design facing globalisation.

As the article will discuss the methods of designing regional interiors, it is necessary to investigate the theory of regionalism. Architecture has discussed regionalism for many years. To the West, regionalism has different connotations in different times. Before modern times, regionalism was differentiated mainly due to physical factors, such as climate, geography and natural resources. After that, regionalism played a role to represent national identity, as European countries became nationalistic. After the Second World War, some architects began to explore modernist architecture with local cultural characteristics. In the 1980s, critical regionalism won wide recognition. Alexander Tzonis and Liane Lefaivre first conceived the critical regionalism concept, and then Kenneth Frampton's efforts led to its wide-spread acceptance, particularly in China, because it tries to search for a balance between the universal civilisation and the local culture (Lu, 2009). Critical regionalism emphasises the tectonic and the underlying logic. At this point, critical regionalism leads to a more rigorous and rational way of dealing with regional culture, while still producing a modern design. Comparably, postmodernism, which considers history a resource to unearth a motif for decoration, designs through collaging different cultural fragments. Thus, sometimes, postmodernism is a shallow way of doing design. Therefore, as for the redesign of blue calico, the tectonic way of doing design would be the basic principle, as the design process would be evidence-based, and its advancement would be rigorous.

3 Design Process

This section introduces a three-phase work-flow model. The model is a design process that showcases the interior design method of applying traditional blue calico elements in modern interior spaces. The design method requires rigorous research and rational pattern transformation for further decision making. The primary question is how to research and transform the traditional patterns of blue calico for its application in modern interior space. Obviously, the answer depends on a work-flow model specifically suitable for the research, transformation and application of the blue calico elements. The article referenced general interior design procedure and the craft-making process of blue calico for inspiration.

The interior design process, regardless of the project's size, generally falls into five phases. Each phase is essential and builds on the previous step until the project is complete. The five phases are programming, schematic design, design development, documents and contract administration (Piotrowski, 2011). The typical interior design process emphasises the technical aspects concerning project manipulation. However, with the more widely accepted emphasis on evidence-based design strategy, increased attention has been paid to initial research and design transformation. Robinson and Parman (2010) defined the research-inspired design process as planning the research, information gathering, programming and design. The process aims to approach interior design as a knowledge-based activity instead of a project-based one. However, giving more consideration to either the research or the project leads to unbalanced interior design. Thus, if these two kinds of design processes combine, the process could be divided into three basic steps, as initial research, pattern transformation and project design.

However, the blue calico creation process is generally practised in multiple steps, which could inspire the work-flow model as well. Based on having practised the craft personally for a long time, the primary characteristic of blue calico creation is reflected in its pattern transformation process, which consists of three categories: the transformation of media, action and colour. In the media category, the pattern is transformed from kraft paper to white

cotton cloth. In the second category, the action changes from carving (kraft paper) to brushing (mixed powder) and dyeing (vegetable dyes). In the colour category, the white cotton cloth turns into a blue-and-white one. Inspired by the craft-making process, this article will explore transformation methods.

These three steps constitute a relatively complete working model, with each step involving different core tasks that form a progressive procedure. First, the initial research focuses on collecting information regarding blue calico and then analysing it to provide a foundation for the following transformation process. Second, the pattern transformation involves a visual analysis of the blue calico, its pattern transformation and its brand identity (to make the serial designs coherent with each other). Third, the project design is based on initial research and pattern transformation. During the process, the work gradually becomes connected to the core problem of how to explore the blue calico's application in modern spaces to represent regional identity. In order to solve the problem, various projects would be introduced to test the design. In these three steps, the preliminary phase of research is relatively abstract; the pattern transformation phase, which brings a variety of possibilities and uncertainties, is semi-abstract; and the project design phase moves towards developing a specific design to solve the problem discussed above.

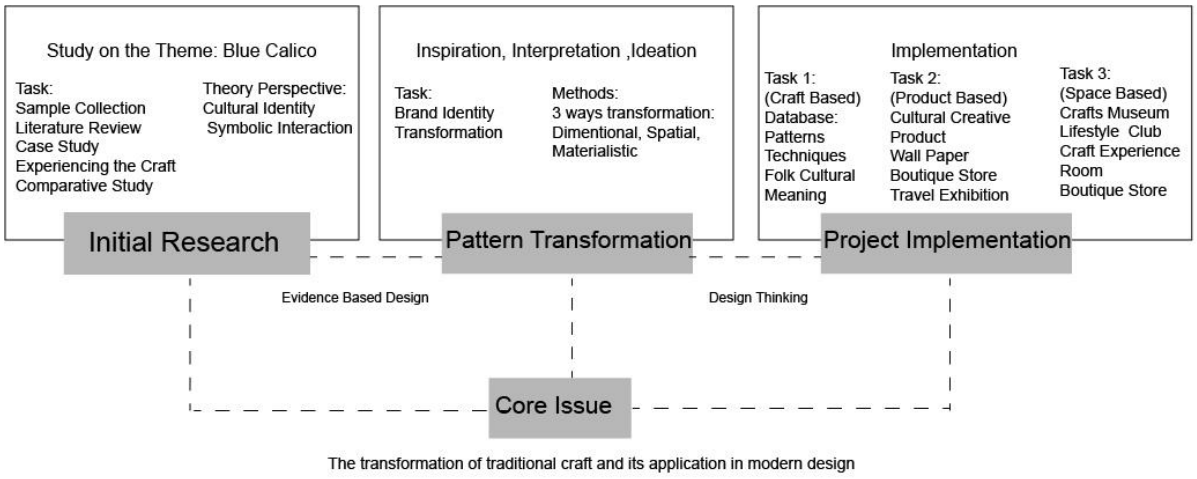

Figure 1. The three phase work-flow model.

3.1 Task module 1: initial research

As shown in figure 2, through visiting the blue calico museum and learning from the craft masters, we concluded that making blue calico requires four key factors: pattern, media, procedure and tool (see table 1). First, patterns are studied for their potential to generate new forms. Thus, the main concerns are the pattern’s cultural implications and its composition (module, grid, hierarchy, etc.; see figures 4, 5). This step’s purpose is interpreting the existing blue calico pattern and analysing the logical relationship between the patterns.

Second, media supports the pattern, which progresses from kraft paper to cotton cloth. The pattern is first carved on the kraft paper using a knife. Then, by scraping the mixed powder, the pattern is attached to the cotton cloth through the engraving. Transforming the media creates a different effect on the pattern. Kraft paper makes the pattern appears explicit, whereas cotton, a relatively soft material, shows natural minor uncertainties, such as subtle crack lines within the pattern shapes, due to the drying process of the mixed powder.

Third, procedure is sequential. The next step always rely on the previous one. It starts from designing patterns to carving kraft paper, brushing tung oil on the kraft paper, drying the kraft paper, moisturizing cotton cloth, brushing the mixed powder through the kraft paper on cotton cloth, naturally drying the cotton cloth, dyeing the cotton cloth, hung up the dyed cloth for air drying, removing the mixed powder from the cotton cloth. The process of making blue calico has been streamlined for efficiency. Different craftsmen have improved and professionalised the craft. In most circumstances, the pattern design, carving process and dyeing process are separated, thus enhancing the quality of the blue calico. Generally, the carving and dyeing processes are the two key steps(see figures 3).

Fourth, a multiple of tools guarantee to accomplish the making process, such as knife for carving on kraft paper, pebbles for rubbing down deckle edges, sifter for separating out the powder impurities, scraper for removing the mixed powder, etc. In old times, craftsmen made tools by themselves.

Figure 2. Initial research through visiting the museum, learning from the craft masters

Table1. The Four Key Elements of Making Blue Calico.

Item	Content							
Pattern	Carved-out pattern				Blue and white pattern			
Media	Kraft paper				White Cotton			
Procedure	Carve a kraft paper template	Brush tung oil	Airing	Scrape dye-resistant paste on cloth	Airing	Dyeing	Airing	Remove dye-resistant paste
Tool	Carving knife	Oil brush	Clamp	Scraper	Pole	Dye vat	Pole	Scraper

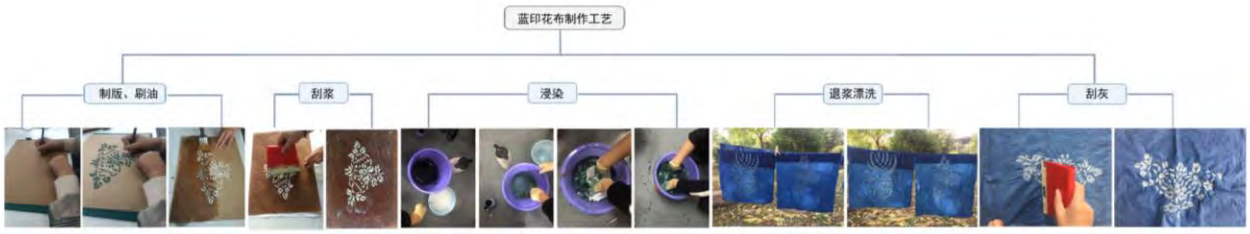

Figure 3. Research the craft by practicing it.

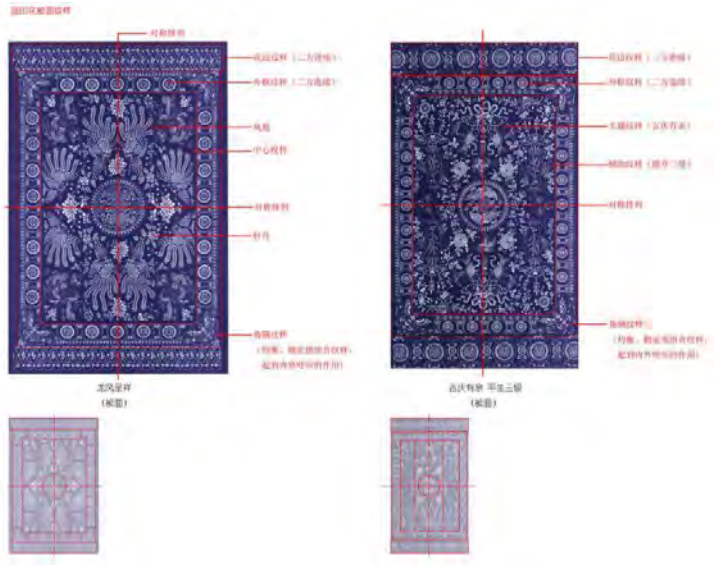

Figure 4. Pattern composition analysis of blue calico.

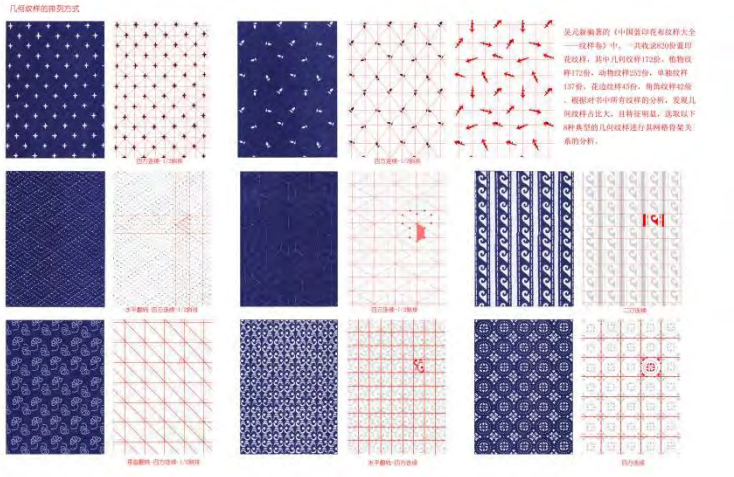

Figure 5. Grid analysis of blue calico.

Regarding the relationship of these four key factors, pattern is the most essential, and the other three are the approaches and tools to realise the pattern. Traditionally, the blue calico pattern design and its transformation is the most difficult step, and it also reflects the creative and aesthetic values as well. Folk artists specialise in designing and making pattern templates that could be reproduced through rubbing them several times. The artists typically design the template from their life experiences and from referencing their predecessors' works, which preserves the folk-custom meaning. By using blue calico in a living environment, people make the interior space symbolic. Thus, pattern plays a vital role in the whole process, with the media, craft and tools serving the pattern. The medium in blue calico is used to meet the need for pattern reproduction, which reduces costs. Tools are used for carving numerous disconnected hollows, which helps to constitute a complete form because of Gestalt psychology, and the craftsman must carve carefully, making certain the cut-out is in the correct size to hook the mortar made of water, soybean powder and lime powder; the craftsman must also avoid making the cut-outs too large, as it could easily make the mortar crack after drying and affect the final dyeing process.

During the research, the process is further studied to understand some specific details in the production process, and the process is visualised through graphic language (see figure 6).

The production experience and the in-depth analysis of the traditional blue printing process by means of literature analysis, observation and recording also builds the foundation for the subsequent designs of related projects. Through experience, it is clear that pattern and colour are the core aspects of blue calico. In terms of transformation and application in the context of modern design, emphasis should be placed on studying pattern and colour to achieve a balance between preservation and transformation.

Blue calico is also a white-and-blue cloth that is produced in many provinces of China, where the method of making blue calico is to cover a piece of white cloth with a paper cut and then to spread a layer of mixed lime, bean powder and water over it and dip it in an indigo dye bath. After being dried in the shade, the layer of the mixture is scraped off, revealing a finished blueprint with two colours, either a white background with blue patterns or a blue background with white patterns. The pictures are usually flowers, human figures or legends. Thus, the subjects reflected on the blue calico make it secular, humane and dynamic.

3.2 Task module 2: pattern transformation

This phase is to perform a variety of possible attempts under the uncertainty brought by the design idea. The initial research stage is relatively abstract and theoretical, while the theme transformation stage is more visual, using visual language for design analysis and research. The morphology of the blue calico craft was deduced on the basis of previous research. Three transformations were noted: material transformation, dimensional transformation and spatial transformation (Ding, 2016). As dimensional transformation is basic for further exploration, the transformation of material and space inevitably involves the change of either dimension. The process of analysing these three transformations is also the process of exploring various morphological possibilities(see figure 7).

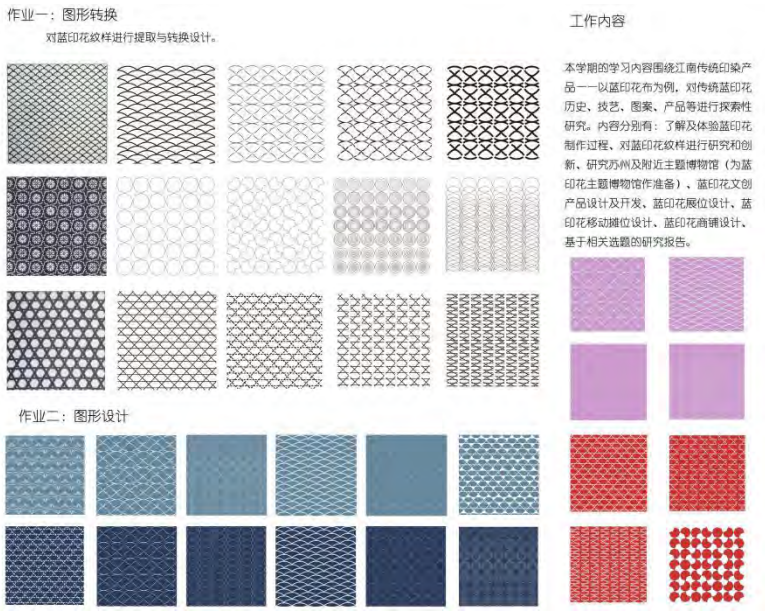

Figure 6. Morphs of patterns.

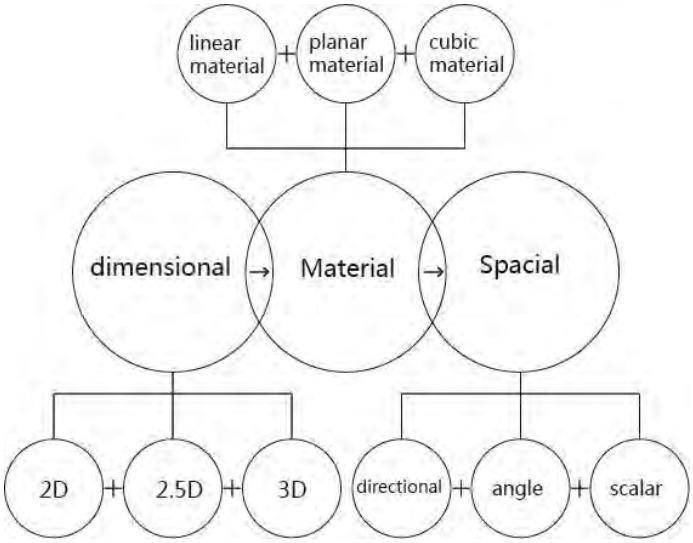

Figure 7. Diagram of "three transformations".

Task module 2 must conduct a morphological exploration and analysis on the basis of the initial research. The morphology collected from the preliminary investigation becomes the basis of the deduction, enabling the exploration of various morphological transformations. The main problems to be solved in the process of morphological inference include how to excavate the morphological source from the local context and perform a rational analysis and rigorous derivation. Furthermore, this task module can also expand the design ideas through the study of relevant cases, for example, through the study of architectural skin cases to master the basic rules of pattern composition, creating a reference for form design. Here, morphological design can be transformed and applied, and various factors, such as dimension, material and space, can be considered when making wall coverings or any installations that could be hung as an interior layer. Among these designs, wallpaper would be relatively simple and concise. Patterns explored during the process could be applied in interior space for further study.

3.3 Task module 3: project design

According to previous research, the design will focus on exploring the application of the craft and its patterns in modern daily lives. As the traditional craft was consistent with the daily lives of the past, it would conflict with what people need today, either functionally or aesthetically. Thus, the challenge is how to transform the craft and its patterns for a modern context. Considering the research question, several different kinds of projects were introduced for testing the possibilities of using the craft and its patterns for the new circumstances. The projects include cultural creative products, a blue calico souvenir shop, a travel exhibition booth, a mobile stall, a craft experience centre and a blue calico museum. For a cultural creative product design that could be used in interior spaces to construct a certain atmosphere, the main focus was on applying the transformed patterns on a new media(see figures 8-10). This process relates to considering material selection, scalar changes and the pattern of context configurations. To continue testing the possible blue calico transformations and their application, pattern research was considered the first priority because it relates to visual branding. Regarding interior spaces, we first choose a modern space to test the potentiality, and then to choose a traditional Jiangnan residential house, which shows consistency with the blue calico, because it was once widely used in the Jiangnan area. The application of blue calico elements in such a context would be normal, and it showcases nostalgia and recaptures old memories(see figures 11,12).

Figure 8. Project design - the application of blue calico patterns on fashion, accessories and interior cushions.

Figure 9. Project design --the application of blue calico patterns on tiles.

Figure 10. Project design -- re-designed patterns and their dyeing effect.

Figure 11. Project design -- the application of blue calico patterns in souvenir shop.

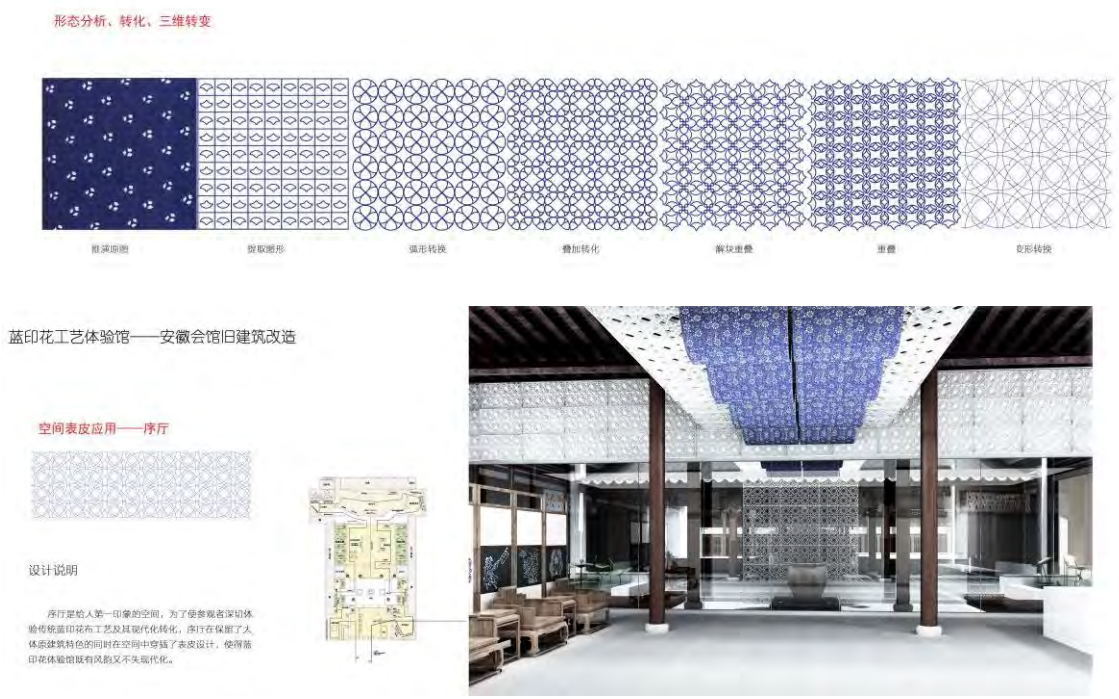

Figure 12. Project design -- the application of blue calico patterns in a museum.

4 Conclusions

The three-phases work-flow model, consisting of initial research, pattern transformation and project implementation, aiming to apply the traditional craft in modern interior spaces. Among these three phases, the initial research works as the foundation for decision making and the project design's evidence-based practice. The pattern transformation builds a connection between traditional patterns and the modern context, enabling the pattern to be used across a wide spectrum of people's daily lives. The project design makes the previous two phases a reality and tests the potentialities of redesigning blue calico.

With the transformation, blue calico's core characteristics are still retained, while discarding its out-of-date elements. Thus, the transformation process results in the sustainable development of the craft, striking a balance between the craft's authenticity and its flexibility towards modern life.

The research′s constraint is that it lacks appropriate consideration of the craftsman′s knowledge and their contribution to the decision making of the project.

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The Poetics of Service: Making in the Age of Experience

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Design is the art of making that mediates universal knowledge and a particular material. How, then, can we explain making in which the main focus is on shaping the immaterial, such as service design? This paper examines the making of the immaterial via a discussion of service storytelling. We use Aristotle's Poetics as the conceptual framework, focusing on the four causes of being and the dynamic structure that unfolds over time. We first discuss Poetics as an art of making that concerns the human experience, regardless of the medium. Poetics explores a systematic structure of drama from a human-centered perspective, which positions the four causes (i.e., material cause, efficient cause, formal cause, and end cause) as the key organizing principles for analysis and synthesis. We then use this framework to (1) analyze service from the perspectives of the four causes, (2) study the key factors and patterns of dramatic structure as a unifier that synthesizes the four causes into an organic flow, and (3) present a case study that applies the Poetics framework to compare accommodation services from two different cultural perspectives: an American inn and a Japanese ryokan. In the conclusion, we highlight the need to explore a participatory model of service storytelling.

1 Introduction

Design is the art of making. The Greek word *techne*, which is the origin of the term "design," refers to the knowledge of making guided by the particularity of the material(s) used. Mitcham (1994) suggested that techne refers to "a special knowledge of the world that informs human activity accordingly." While Plato distinguished between techne (the knowledge of making) and episteme (universal knowledge), Aristotle argued that techne is knowledge that is interactively mediated by the sensory perceptions of materials and the systematic knowledge of logos (Mitcham, 1994); in other words, making is knowledge in action, which connects materials and ideas. This view resonates with Schön's (1992) discussion of design as a reflective conversation using the materials of the given situation.

If making is particular to material, however, how can we understand making in design projects where immaterial concepts, such as system, interaction, information, or services, are central to making? Ingold (2007) discusses the dichotomy of matter and mind to propose that materials do not exist as fixed attributes, but "occur" in an environment as they are experienced as stories and histories. To study the interactive and integrative nature of making, we draw on the theory of storytelling, which is an archetypical framework for the analysis and construction of immaterial

human experiences. Storytelling is an art of making, capturing the pattern of life that people can understand and reproduce.

This study particularly focuses on the making of service. Although several researchers have proposed the dramatic potential of a service (Evenson, 2005; Moggridge, 2008; Pine & Gilmore, 1998), this approach often interprets service as the performance of the service provider and regards customers as a passive audience. Through storytelling, however, the audience becomes an active participant, thus building new meaning on top of the structure of the service system. There is a need to examine service storytelling as a co-creative process of making rather than one-way communication.

Storytelling has widely been used in the design process as a tool for research (Wilkins, 2004), prototyping (Quesenbery, 2010), and communication (Lichaw, 2016). The present study focuses on storytelling as a theoretical model, drawing on Aristotle's Poetics as a structural framework to understand service and its making. The following sections will (1) examine service through the lens of the four causes of Poetics, (2) study the key patterns of dramatic structure as a unifier that synthesizes the four causes into an organic flow, and (3) present a case study that applies the poetic framework to a comparison of the American motel and the Japanese ryokan.

2 Poetics

Aristotle's Poetics was the first historical work to discuss drama and has since become the foundation of storytelling theories. The name "Poetics" originates from the Greek word 'poieîn' (to make). Often misunderstood as a study limited to poetry, tragedy, or theatrical play, Poetics represents a broader discussion about "the art of making" that deals with human experience, regardless of the medium or content. Aristotle viewed drama as mimesis (the imitation) of nature and thus proposed a systematic method of making to conceptualize the human experience as a representation of reality.

Poetics encompasses a theory about a comprehensive and conclusive "structure" of experience. It was written during a time when popular media was transitioning from oral accounts to written text. Dramatic performance was a component of poetry, which was narrated by bards and the techne of making was perceived as a form of inspiration by divine madness. As character was invented, however, poetry eventually evolved into a collaborative theatrical performance, with the poet giving directions mediated by written scripts. It was during this period when Aristotle sought to develop a theory of creation. He studied making in relation to a systematic principle, such as human nature and causality.

Poetics represents a study of the human experience. The main reason that Aristotle focused on tragedy is not necessarily due to the subject matter but, rather, to its structured plots, with human subjects at the center of the experience. In ancient Greece, epic poetry was considered the opposite of tragedy, the former of which was

a lengthy historical record that was passed down orally and added to by generations of bards. Therefore, rhythm and rhyme—operating as mnemonic devices—were more important than the holistic structure. In contrast, tragedies were shorter, stand-alone performances with a clear beginning and end. Intense emotion was used to blend each part into an integrative flow. Aristotle devoted a considerable amount of Poetics to explaining the superiority of tragedy over epic poetry, as it was a “human art.” Naturally, Poetics evolved into a theory that discusses the essence of the human experience and values.

The human-centered perspective of Poetics renders it relevant to the present-day framework of storytelling, which encompasses different forms of media and technology. For example, Laurel (1991) applied Poetics in her discussion of human-computer interactions. The rationale behind analyzing contemporary technology through the lens of a classic framework is because Aristotle’s theoretical model still offers insights into how we create intangible interactions. As such, Aristotle’s theory, which discusses all kinds of creation as forms of mimesis, can be applied to any making of the artificial—irrespective of whether it is material or immaterial.

In the field of design, Poetics is understood as a structural theory of making, thus providing a basis for the study of design as a productive science. According to Buchanan (2007), design science refers to the process of making, during which functional elements are analyzed and synthesized in an organic manner. He argued that Aristotle laid the foundations of design as a productive science by discussing integrative actions in relation to production. Moholy-Nagy (1944) also proposed Poetic analysis and synthesis as the core processes of making. He compared the design process to that of nature’s trial-and-error process, thus positioning materials, techniques, forms, and artist’s role as the key elements of making.

The systematic structure and human-centered perspective of Poetics as a productive science makes it a useful framework for understanding the making of service. In particular, Aristotle proposed four causes to explain the causal relationships between the essential elements of making and the outcome: form, function, material, and manner (see Figure 1). In the following sections, we will analyze the essential elements of a service with these four causes.

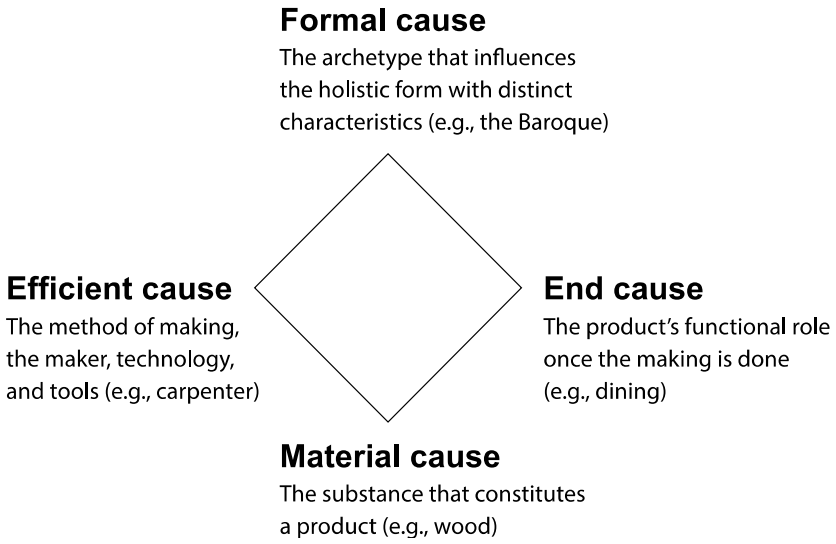

Figure 1. Aristotle's four causes.

3 Analysis: the four causes

3.1 Material cause

Material cause refers to the substance that constitutes a product; for example, the matter that comprises a chair could include wood, plastic, or metal. Regarding the study of service, while its immaterial nature (i.e., intangibility, heterogeneity, inseparability, and perishability, or IHIP) has been emphasized in marketing (Vargo & Lusch, 2006), Shostack (1997)—creator of the service blueprint—proposed that material and immaterial elements must be combined into a molecular model. In the present study, we draw on Aristotle's Poetics to understand the organization of the material and the immaterial from the perspective of human experience.

According to Aristotle, the most basic matter of drama is *enactment* (i.e., everything perceived with our senses). In service, the most basic element that corresponds to enactment is the touchpoint—the "moment of truth" in which the customer feels and recognizes the service. Many companies place tangible elements at these touchpoints to influence customers' perceptions and assist in their interactions with the service. In this way, the intangible service is mediated and consolidated by products such as uniforms, chairs, and brochures.

A collection of enactments become *patterns*. Dispersed touchpoints are meaningless if they are not integrated; they must be properly connected to guide customers from advertisements to websites, and eventually to the place where the service takes place with clear meanings about each touchpoint in relation to another. As customers are considered outsiders who are unfamiliar with the service, information design is crucial to mediate patterns, which can be visual, textual, or auditory.

Pattern serves as a compositional element of *language*, often represented by a service script. Service employees use standard lines of speech with a specific sequence and flow. If a pattern corresponds to a scripted line, language determines

how the lines should be combined into a script to support a unit of activity; for example, a certain set of questions and answers are required when a customer checks in at a hotel. The service script, as a unit of communication to support customer action, can also include non-verbal forms of communication, such as spatial layout or digital interfaces.

Language is the expression of *thought*, which includes the customer's cognition and emotion while conjecturing the logic behind a service. Thought is often expressed through language; for example, the musical tone and polite script of call center representatives are a deliberate display of a customer-friendly service. Thought can also comprise the philosophy behind a service—often manifested in a manual that guides employee decisions and actions. The manual reveals whether the principles of a service prioritizes the customer's need or the company's profits.

Thought collectively form the *character* of a service. In the service industry, there are clichéd standards of hospitality (e.g., the uniformed staff of high-end hotels). These characters perform their roles to define the situation of the service and, in turn, the characters of the customers (Goffman, 1978). These characters are not just individuals; they are symbols that manifest the argument of the service as a whole. Similar to a dramatic performance, a specific hairstyle or fashion can strengthen this role and its associated functions.

Aristotle stated that action determines destiny, while character determines temperament. As an idealized model of human action, dramatic *plot* consists of causally interrelated and holistically fused incidents within a certain flow. Service is also comprised of a plot—one which logically and emotionally supports an action with a practical purpose. As such, the entire service plot should carefully streamline and coordinate each step and piece of information so that it supports collaborative problem solving between service providers and customers.

3.2 Efficient cause

Efficient cause includes the method of making, the maker, technology, and tools. For example, two sculptors with different techniques and tools will achieve different results, even if they work with the same materials. In service, there are many efficient causes other than the creator—who is the traditional efficient cause—because diverse stakeholders are involved in the process of making. The final service is co-produced on the spot as a collaboration between the service participants, including service employees and customers.

A *designer* is an author of the product that they make, but service design authorship is different from traditional art, in which a single author assumes ownership. Service design is usually performed by a multidisciplinary team from various backgrounds, thus infusing diverse skills and knowledge into the design. There is still a trend in art and design culture to highlight a star creator as the author, even in team work, which can be explained as the human tendency to define an efficient cause. In many cases, service authorship is retained by the service organization.

According to the perceptions of those who co-create a service, the character and identity of the *organization* can often serve as the efficient cause of the service. Branding plays a critical role here, as the character of the company is usually symbolized by a company logo that must be managed and reflected through advertisement, thus permeating all service touchpoints in a consistent way.

A considerable amount of decisions about a service are also made by the *manager*, who operates on the frontline. Similar to a director, service managers reinterpret and reproduce the service on a daily basis. Among small-scale service providers, the planner, manager, and provider may be the same person; however, in large service organizations, managers have an independent influence as an efficient cause. Despite its evident importance, the role of service managers is less frequently discussed in design.

In addition, just as the same play can be performed differently depending on the actors, the same system can offer different services depending on the *service workers*. Service workers represent the character of the service and act as touchpoints in which customers interact with the service. The personality of the service representative significantly influences the customer's overall perception of the service, which is especially true for small, local services.

Customers also represent a key efficient cause because they participate in service coproduction, especially when considering that service quality is determined by customer subjectivity. Unlike material objects, which end when consumed, service customers continue to return to the service and use word-of-mouth advertising to inspire new customers; therefore, existing, former, external, and prospective customers are all important efficient causes. Customers' past experiences, as well as those of competitor services, need to be considered to devise better ways to encourage the coproduction of personalized experiences.

3.3 Formal cause

Formal cause influences the holistic form of service by characterizing it with distinct features (e.g., genre and pattern). It is difficult to define a service, because everything in the human world can be interpreted as a service—even physical objects (i.e., services mediated by a material interface). For example, a washing machine could be considered the materialized form of a laundry service. What, then, is the formal cause that influences people to perceive a service as a service?

One characteristic of service is that "care" for customers is systematically built into its form, which makes people perceive it as a "service". Therefore, care should be embedded into the form itself as a natural characteristic of a service, rather than relying on the individual decisions of service workers. For example, service designers and providers should not expect individuals' random favor to help wheelchair users; instead, there should be a guideline in place (i.e., a manual for service workers), and the system should have an inclusive design (e.g., an automatic door).

Second, service is a form of practical problem solving. People may not know what their own needs are; thus, the challenge is to uncover the fundamental problem and support resolution. In classic storytelling, the hero is often unaware of the central dilemma and thus seeks the help of a mentor to confront it. By the end, the hero reaches an understanding of what has been lacking and thereafter returns to the origin of the problem to resolve it. Similarly, the role of services is to help the customer gain autonomy in the process of overcoming a problem (Kim & Lee, 2017).

Third, service can have a distinctive genre. In storytelling theory, genre refers to a composition characterized by similarities in pattern, rule, style, or subject matter. Services likewise have distinct patterns. In many hotels, for example, room service staff are often on standby until midnight—despite this being an unprofitable practice—because room service is an essential part of high-end accommodations. Cultural factors also have great influence on genre, as the same service could take on different forms in each culture.

3.4 End cause

The end cause is the functional role of a product. For example, a museum building has the functional role of art exhibition. In the case of service design, the end causes can be classified into a functional goal within the service, as well as a broader social purpose to be fulfilled. This duality resonates with other twofold structures of service, such as core activity versus peripheral activities (Gupta & Vajic, 2000), or the technical quality of the outcome versus the functional quality of the process (Grönroos, 1990). The main function of a service (e.g., car repair) is to solve the highest priority issue, but human treatment and emotional experience are also critical to the perception of service.

In this respect, catharsis is another important end cause of a service. According to Aristotle, the goal of drama is to relieve emotions by imitating actions—in other words, catharsis. We argue that service catharsis is also twofold; although it occurs when a core function is performed (e.g., having a meal at a restaurant), there is usually another cathartic touchpoint when identity-related emotional needs are fulfilled (e.g., blowing out birthday candles at the restaurant, despite the main function of dining).

In addition to addressing a particular need of customers within its boundary, a service is often offered in the context of a complex ecology. Service systems usually operate together interactively, as the output of one service can directly influence another. Certain services are positioned within a broader service, which are generally less relevant to the core function but may work as a process to define the service organization’s or a user’s identity. From the customer’s perspective, these services are positioned to serve partial functions in the ecosystem where the customer’s life is at its center. Some services can help fulfill goals that are outside the service boundary and interrelated to communities where the service organization is operating in. Therefore, social values cannot be ignored by a service when we consider the end cause.

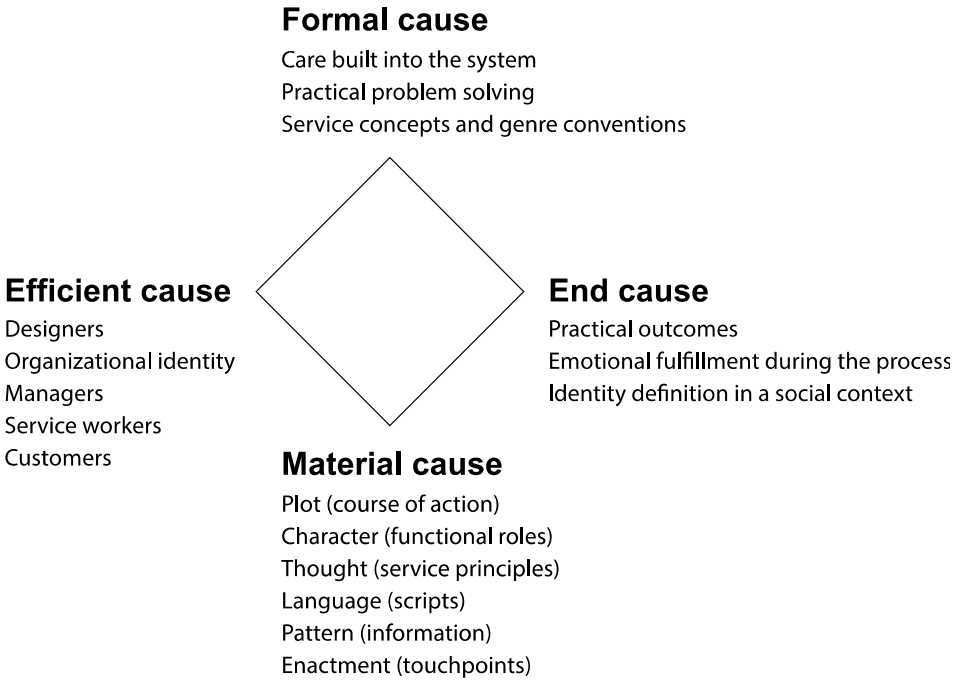

Figure 2. Key elements of service analyzed via Aristotle's four causes.

4 Synthesis: dynamic structure

We examined the key elements of a service via the four causes proposed by Aristotle, as shown in Figure 2. However, making requires much more than analysis. Poetic synthesis refers to a process of dynamic inquiry that integrates the elements into a unified flow with emotional integrity. In this section, we will review the patterns of organic structure that combine the elements and components of a service.

4.1 Beginning

While some argue that physical location is the launch point of a service, from the customer's perspective, service begins with a deficiency, need, or desire. Therefore, an advertisement can function as the place where customers and a service first interact. An advertisement makes a promise, which is subsequently fulfilled when a customer arrives to receive the service. For example, a customer may book a room at a luxurious hotel, as per an advertisement's promise, and the hotel offers various types of evidence, delivered at touchpoints, to prove that the initial promise is being fulfilled.

At the entry point to a service, it is important to communicate the whole picture to the customer so that they will form a proper expectation. This holistic image is called the "service concept," which strategically and consistently brings together every moment of a service (Goldstein, 2002). The service concept informs customers about the value of the service, the overall structure, and the intent, thus giving them a better sense of what to expect from the service and how to participate in it.

4.2 Turnabout

Once they grasp the whole picture, customers will participate in the process of service coproduction, which is presented as a flow with increasing causality toward a plausible ending. However, the experience will lose its integrity if the story just arranges static steps toward the anticipated ending. Aristotle introduced the concept of the “turnabout” as a sudden change in plot toward an unexpected direction. In a service, turnabouts should not be unpleasant or disappointing; rather, they should be happy surprises, such as a complimentary bottle of wine, that will enhance the perceived service quality. Another case of turnabouts is often observed when a customer makes a mistake during service coproduction. Instead of causing the service to fail, however, the service provider often intervenes to shift the entire plot toward a happy ending.

4.3 Climax

According to Dewey (1934), emotion is the unifying quality of an experience that moves and changes as the experience develops. Climax is the most intense moment in this dynamic flow, often accompanying emotional catharsis. The structure of progression, turnabout, and climax builds up the customers’ expectations toward the moment of realization, thereby leading to the pleasure of discovering the answer to their inquiry. The climactic moment of a service would be when the functional problems are resolved and the needs of the customer are fulfilled; however, the experiential aspects of this process, such as treatment and care, are just as important as the function. Emotional catharsis stems from the customer’s perception of a positive identity through carefully orchestrated treatment. In high-end services, the climax is usually created through the experience of becoming who the customer desires to be, with the support of the service.

4.4 Ending

Most services have a ritual to signify the moment of closure, such as when a service worker hints that the service has ended, often with the payment bill, followed by the customer’s action of leaving the service location. However, the evaluation of service quality is often done after the customer has left (i.e., when they reflect on the overall experience). Therefore, every customer perceives the ending of a service differently. Like the ending of a play, customers can expand the service story to contextualize its function and meaning within their lives, as well as deciding whether they should return to the service again. Hence, services should be designed with the recognition that every ending represents the beginning of the customer’s next experience.

5 Case study

In the following sections, we present a case study that applies the Poetics framework in the comparison of American motels and Japanese ryokans. A typical motel offers economical accommodations for quick stays, whereas ryokans are a traditional healing space to enjoy hot spring baths. Both are accommodation services, but their storytelling models differ in terms of their four causes and their dramatic structures.

5.1 Material cause

In American motels, touchpoints are minimized because the formal and end causes aim for simplicity and effectiveness. Interactions with staff are typically confined to check-in and check-out procedures. This indicates that the standardized patterns of the motel, such as typical floor plans, are given more importance over customer experience, thereby revealing the utilitarian principle behind the service. Customer and the service provider interact via quick, functional transactions, which represents the plot of the service.

In contrast, Japanese ryokans comprise rich, diverse touchpoints that make each experience unique, including the customer's entrance into the ryokan, the serving of a kaiseki dinner, and the customer's wearing of a yukata and entrance to the hot spring baths. Staff are well trained in voice, appearance, and posture as they escort the customers through the premises and introduce them to the baths and meal customs via a pre-determined script. Ryokans have an invisible manual through which they tailor their services, based on the principle that the customer's rest should be the top priority. While playing their roles, ryokan staffs exhibit unique characters, often reflecting the cultural image of that particular ryokan. The harmony of these elements altogether creates the integrated plot of the healing experience.

5.2 Efficient cause

When it comes to efficient cause, most motels are designed by large hotel franchises, which create services that fulfill their functions regardless of location. Planning and production are separated in this mass production of service; therefore, if localization is needed at the production level, the manager of each branch will take charge in the redesign of the service at the micro level. While the brand image of the hotel chain has major influence on this service system, the roles of its employees and customers are minimized. Receptionists are typically part-time workers, and customers are often treated as the material resource of an efficient service factory, rather than co-authors of a service experience. Behaviors outside the standard framework are discouraged.

Ryokans, however, are often run by a family for generations. The owners typically inhabit the character of traditional kimono-wearing women and play multiple roles of a manager and a worker. It is also notable that Japanese culture is a key efficient cause in this case. Ryokans sometimes belong to a village that collectively designs and manages brand identity, therefore acting as the bearer of Japanese tradition and culture. Ryokans as a service have been largely shaped by history and media, which creates a shared image that allows both service workers and customers to subconsciously play their expected roles and participate in the service performance.

5.3 Formal cause

The utilitarian form of the American motel can be considered an outcome of the nomadic culture represented by automobiles and airplanes. Because the main customers of American motels are travelers, the form is designed to meet their needs. Indeed, economic value is the most important character of this genre, and

their basic functions are compensated for by their low prices. For customers weary from travel, speedy check-in and check-out procedures are the best care. These motels also have vending machines for those who have to leave early in the morning, and a parking lot design that allows customers to park right in front of their rooms so they can leave quickly.

The ryokan service, on the other hand, has a much more sophisticated form—one that is almost like a ritual. It provides customers with various types of care while satisfying their practical needs for food and bath, thereby helping them enjoy mental and physical pleasure and escape from their daily lives. The multi-course kaiseki meal, which is served in the guest's rooms, represents the climax of this genre, which is offered in a similar fashion at any ryokan. Both ryokans and motels are hospitality services, but even within the same category of service, their variations in genre render the forms of each experience as dramatically different.

5.4 End cause

Motels have a practical end cause, as customers are simply looking for a place to stay the night while travelling and usually leave early the next morning to continue their travel. Because this service is positioned as a supporting role in the customer's higher-level action goal of travel, it is crucial to that motels offer connections with other services (e.g., airport shuttles). Aside from their basic function to fulfill the safety and sanitary needs of customers, many key functions are outsourced (e.g., pizza delivery brochures). Motels are often located in big shopping malls to enable speedier connections to other services.

In contrast, a ryokan is often a travel destination in itself. For example, Takahan Ryokan, where Yasunari Kawabata famously wrote the Japanese classic, *Snow Country*, has deliberately preserved the room he stayed in and recreated a selection of scenes from the novel. Anything old only positively reinforces the identity of ryokans as originating from Japanese tradition, because the end cause has been altered from offering lodging to experiencing history and culture.

5.5 Beginning and end

In American motels, the beginning and end are rather simple: Customers glance at the motel's road sign to check vacancy, then momentarily pause their journey to stay overnight. At the end of the service, customers check out of their rooms to resume their journey. Customers are not likely to return; however, those who are dissatisfied may leave a negative review, thus affecting the ability to attract other potential customers. Taking all this into consideration, the concept of the service and all its elements are designed to be lean and efficient; the service process has a fast rhythm, and the beginning and end are hassle-free.

The beginning of the ryokan service is completely different. As the main reason to visit a ryokan is to enjoy a relaxing retreat, customers often collect information and compare options before making a reservation. The service concept typically includes a beautiful scene of a traditional kaiseki meal as a marketing tool. The actual

beginning of the service is quite ritualistic: a pick-up service from a nearby transportation hub to the ryokan, with a personal greeting from the owner. Once the customers are introduced to the premises, they interact with a cascade of memorable touchpoints. The service is finally concluded by a clear closure, marked by same shuttle service—this time back to the transportation hub. A special souvenir is sometimes gifted to the customer at the end, which is intended to serve as a new beginning for returning customers.

5.6 Turnabout and catharsis

In American motels, one of the key moments in the entire service is when the customer takes a shower and goes to bed. The feeling that they are in a safe room—not on the road at night—is almost cathartic. The next morning, however, when the customer departs, the feelings of relief they experience from, for example, having left on time to catch their airplane are even closer to the moment of catharsis. In this sense, lodging was not the purpose of the stay; the moment when the customer begins their journey again is the true climax.

In ryokans, the service experience is designed in a way that the climax may be experienced at multiple touchpoints, thus leading to an anticipation of the next cathartic moment when, for example, the customers are served a Kaiseki dinner, experience the hot spring baths, enjoy a local village festival while wearing traditional clothing, and anticipate returning to the ryokan as a regular patron.

6 Conclusion

This study drew on Aristotle's Poetics to study an "art of making" that centers the human experience as a framework for understanding the requisite elements and structures of service design. We analyzed the four causes of service and the dynamic structure of storytelling, which synthesizes these elements into an integrated whole, before finally applying them to a case study of American motels and Japanese ryokans.

The making of services is a co-creative process in which multiple causes and agents are involved. One unique aspect of service storytelling is that customers are not just a passive audience but active participants. Service workers who play functional roles, as well as other customers at the service location, also collaborate in this coproduction. Although the overall structure of a service is informed and orchestrated by design, the participatory nature of service calls for further exploration beyond the static and pre-set notions of storytelling with a fixed plot.

There is a need for research on a participatory framework of service storytelling that enables participants' autonomous action in diverse and personalized ways. The dynamic structure of Poetics offers a foundation for the collective inquiry into problem solving and learning through service storytelling, in which people who have never met before participate in the coproduction of a service. Future research will approach service as a customer-centric inquiry, thereby investigating how services with diverse efficient causes can help stakeholders collaborate.

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Unlocker vs. Onlooker. How can an innovative application of perspective instigate new insights on perception.

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Since its 'invention' in the Renaissance, linear perspective has dominated (architectural) representation and spatial understanding in the West, providing a geometrical tool for a two-dimensional rendering of space. This doctoral design driven research however argues that there is a hidden potential to perspective as we know it and that it could be employed as an innovative actor in the process of (three-dimensional) space-making as well. Furthermore will this generation of new spatialities provoke further reflection on how we look at space and aim for a shift in perception.

In a search for revealing the assumed formative features of perspective and its consequences for our way of looking, this research operates behind Giotto's Proto-Renaissance fresco 'The Birth of the Virgin' (1303-1305). Through performing analogue perspective drawing experiments, we are able to penetrate the picture plane and (re)construct possible versions of the depicted architecture. These new spatialiaties subsequently serve as accessible looking machines. The flexibility and instability of these fictive fields allow for a context where confusion and ambiguity (characteristic for Proto-Renaissance depictions) are tolerated and, moreover, stimulate the emergence of creative insights.

This paper will elaborate on the intermediary research output of this doctoral research project in search for the establishment of a new method of dealing with perspective as a geometrical construct and how it could challenge our spatial perception which is affected by perspective as a cultural construct.

Keywords: perspective, analogue drawing, design driven research, Proto-Renaissance

1 Perspective and its hidden potential

Linear perspective, allegedly 'invented'1 in Florence by architect-engineer and sculptor Filippo Brunelleschi in early fifteenth century, and some years later widely spread through De Pictura – the first treatise on this subject, written by architect and theorist Leon Battista

[1] Or re-invented according to some. White's book *Birth and rebirth of pictorial space* (1972) refers to perspective in antiquity (e.g. the fish-bone perspective that was discovered in Pompeiian wall paintings). And also Edgerton's *The Renaissance Rediscovery of Linear Perspective* (1976) turns back to this period to start his chronological outline with (Andersen, 2007).

Alberti (1435) – was a key feature in the emerging Renaissance and “offered the West what convention had turned into the most realistic method of representation” (Scolari, 2012). Until today linear perspective plays a significant role in (architectural) representation and spatial understanding. More than simply a way of representing, it is a mathematical system to evoke the impression of a three-dimensional view on a flat surface. The construction of such a perspective, also referred to as one-point perspective, pivots on the vanishing point: a specific point located on the horizon, in which all orthogonals (the parallel lines perpendicular to the picture plane) converge. The vanishing point is in close connection to the point of view of the presumed spectator. Due to perspective being a convention and to its geometrical nature, offering a very rational and measurable projection, the conception of perspective being truthful when it comes to reality, or even scientifically capturing ‘the real’ prevails. This reading, however, is a delusion. Applying a systematized technique with the allure of canvassing veracity, does not consequently result in objectivity. The perspective image is a choice and an abstraction constructed by/for the onlooker, for only one immobile eye is actually considered and the curvature of the earth and our retina is disregarded (Panofsky, 1991).

Ways of depicting space have always been determined by the current way of thinking about or understanding space. Before Renaissance perspective, other ways of representation were common, depending on the needs of the spirit of time. Michael Baxandall (2011) refers to this as the ‘period eye’. He states that a specific pictorial style (with its own representational conventions), comes forth out of the cognitive style of a society with its own time-related social characteristics and visual skills and habits. Perspective is thus not only a geometrical but also a cultural construct (Panofsky, 1991; Damisch, 1994). In the centuries following classical antiquity and before the establishment of Renaissance one-point perspective – the so called medieval period – rather flat representational traditions were adhered to[2]. Over time the depth-less depictions evolved towards a deeper exploration (and a gradual systematization) of the third dimension: the interest in pictorial depth reemerged. Seeing perspective as the final result, the ending point of this evolution in representational styles, however, would be wrong. All traditions are authentic and autonomous in their own right, in their own context. They should not be considered as mere predecessors aspiring to develop a mechanism like Brunelleschi and Alberti have constituted (Panofsky, 1991; Florensky, 2002). Looking today at drawings or paintings of the Proto-Renaissance, with our taught convention dogmatically controlling our perceptional abilities, they may be interpreted as deformed or ‘wrong’, but each manner of depiction has been exactly what was required at its time – there is no ‘right’. The use of architecture and the characteristics of these kinds of spaces are intriguing, and the distortions can be considered as full of opportunities for this design driven research. These ambiguous spatial suggestions that we can detect (when not adopting the cognitive mindset hence the pictorial style of the artist), is what we will subsequently further draw upon and what will provide us with a fictive territory where we can test and provoke the characteristics of the perspectival paradigm.

With the relation between what we see and what we know never settled (Berger, 2008), this research aims to critically question the perspectival dogma in our spatial production and understanding as architects. For doing (designing) and thinking (perceiving) are strongly intertwined in the generation of creative and knowledge production, in architecture practice in general and this design driven research in particular. In order to defy the perspectival

[2] A brief digression on Early-Christian and Byzantine art will follow in the next section.

paradigm, two innovative and interconnected shifts are aimed for: liberating both (1) the practical process and the (2) mental one from the dominance of linear Renaissance perspective.

(1) On the practical level, we approach the conception of perspective as a geometrical construct, aiming for a shift in use: unlocking perspective's potential to become an innovative 3D tool that gives access to a milieu of spatial possibilities. This takes place within 'The Act of Space-making'.

(2) Following from these pragmatic explorations, we will subsequently address the intended shift on the mental level. In this context, perspective is engaged as a cultural construct, shedding the dominant paradigm and opening up for a more conscious way of 'The Act of Looking' – a shift in perception.

Within this bigger research context, this paper will zoom in on the first case that was subject of investigation: The Birth of the Virgin, an Italian Proto-Renaissance fresco by Giotto (c. 1267 – 1337). 'Making', as one focus in this call, is on the one hand addressed in the process, for 'thinking through making' serves as the generator of this design driven research. On the other hand it is addressed in the objective: coming to a new understanding of architectural space through the constitution of a new (perspectival) drawing method.

2 Historical Context: Proto-Renaissance & Giotto

The Proto-Renaissance (Burckhardt, 1868) is the name given to the period of the duecento and trecento, the transitional stage following the late medieval period and preceding the Renaissance, and will serve as the context for our research explorations. In order to briefly describe this transition that took place, a short outline on Medieval art will follow here. Approximately around the 3rd century, Early Christian art started to show and artists steadily embarked on a decline in pictorial skills, renouncing the three-dimensional. With the spread of the Christian doctrine, and therefore also its anti-illusionism, the flat space of Christian mythos was opened (Scolari, 2012). Man was supposed to suffer and show devotion. The focus lay on the divine and prayer, and the mere function of images was not to engage imagination. Pictures were not employed in a striven for equaling reality, but as a way to inform the illiterate of the scriptural stories (Baxandall, 2011). Aspects of scale, proportion, the illusion of depth… were not given much attention, for veracity was no objective. Around 600 the Byzantine influence starts to manifest itself in Italy, as well pursuing the two-dimensional and producing abstract symbolic rendition: "a Christological narration in which the third dimension had been deactivated" (Scolari, 2012). Forms are now reduced to line drawings, showing no shadow, no depth. There is no attention for detail, nor correctness: they are now dealing with prototypes.

In the West, a representational shift came about in the 12th century (the prelude of the transitional period of the Proto-Renaissance), following a change in spirit. The theological straightjacket was thrown off. With the prospering of new mercantile and urban political ideas (Edgerton,1976), and with the regained interest (helped by the translations from Latin or Greek into Italian vernacular) in (scientific) classical manuscripts (Vitruvius, Plato…), a rational and profane thinking was introduced (Scolari, 2012). In this context also a new (consciousness about) art emerged, shedding off the iconoclastic tradition and enabling a transition from being allocated to the artes mechanicae to being conceived as artes liberales. Adding to this was the 13th century founded order of the Franciscans, which entailed a revival of humanism: the life of saints in particular (and the naturalistic simple life in general)

became of focus instead of the glorification of the divine. The point of view of man in relation to space became the subject of interest.

A city that played a key role in this new Italian civilization was Florence, and it's here that one of the greatest masters of the Proto-Renaissance came from: Giotto di Bondone. He is seen as one of the first painters to rigorously explore and display pictorial depth, grounding the figures, shadowing them and giving them personalities with emotions: bringing in naturalistic characters and characteristics instead of prototypical sameness. The tracing of lines in the painting was no longer a mere contouring, but it was an interacting within a three-dimensional space, even though not yet mastering the geometrical 'correct' system of linear perspective that would be found out about more than a century later by Brunelleschi, providing the West at that time with a method and a new convention to produce "the most suitable symbolic form for representing the world" (Scolari, 2012).

The fact that Giotto's 'naïve' and 'distorted' representations are not in accordance with how we have learned to depict and perceive space is triggering and this confrontation will help to challenge ourselves by defying on the one hand our conventionalized way of applying perspective and constructing space (practical level) and on the other hand our perceiving and understanding of space (mental level). The spaces that Giotto has created are interesting fictive fields that offer opportunities to critically question and deviate from our own visual and formal habits, and to learn about those by seeing them in a new light. The discrepancy in his Proto-Renaissance style, being on the border of recognition and a different conception offers cracks of ambiguity to explore in, what may lead to an innovative method of generating and understanding (architectural) space within an unlocked milieu of possibilities.

3 Case

We have set up a trip to Giotto's Italy to behold his frescoes in real life, within their architectural context, to be able to literally take position towards them and to relate oneself to these big works of art. The three sites that one still can visit and that can be identified as representing three periods in his development (Van Vechten Brown & Rankin, 1914) were looked into. The Upper and Lower Basilica of Saint Francis of Assisi, is believed to be an example of his earlier style[3]. The Scrovegni Chapel in Padua shows Giotto in his early maturity. Cole (1976) draws attentions here to the painting being executed with more confidence and "the figures seem to occupy space more decisively". In Florence, his style has reached its highest point in the Peruzzi and Bardi chapels in the Basilica of Santa Croce, exhibiting more complexity, but less spontaneity (Van Vechten Brown & Rankin, 1914).

Within this research project the Scrovegni chapel (Figure 1) was chosen to bring forth the selected case. The frescoes, completed in 1305, show a progressive nature of change in Giotto's work which, paraphrasing John White (1972), reflects the growth of an idea within the mind of an artist who was sensitive to the disruptive forces being unleashed by the reconquest of pictorial space (a new visual world still in the process of creation). So on the one hand this chapel is chosen for its inside because it "contains the most extensive and

[3] Although this statement can be contested in two ways. On the one hand there is no actual proof of the fact that Giotto is the artist who executed the frescoes in Assisi. On the other hand there is no information on the date of the frescoes in Assisi, so there is no general agreement on the consecution of the painting. White (1972) for example is convinced that the Arena Chapel has been painted earlier in date than the frescoes in Assisi.

best preserved of Giotto's fresco cycles" (Cole, 1976) and for its content which shows a strong and sensitive three-dimensional quality of compositions (White, 1972). On the other hand the chapel, commissioned to Giotto by the money-lender Enrico Scrovegni, is chosen for the building itself. This freestanding building, belonging to the family palace, provides us with a comprehensible and clear context. The small barrel-vaulted building, has no plastically dividing architectural elements, besides the six window openings in one of the walls. The walls are entirely covered with frescoes by Giotto: three tiers can be discerned depicting the life of the Virgin, her parents Anne and Joachim, and Christ. At the base, below the lowest band, is a row of grisaille panels of allegorical figures representing the Virtues and the Vices. The ceiling is painted in a deep blue, adorned with stars. Because of the bareness of the architectural context, the space can be perceived as an uninterrupted whole.

Figure 1. The interior of the Scrovegni Chapel, Padua.

On some of the frescoes the scene takes place in a landscape, in others architecture is involved. The autonomous architectural objects, or 'mimic boxes' (Longhi in Tamburelli, 2017) wherein the figures are crammed, are shaped by these exact actors: the 'building' is molded around the gestures of those inhabiting the space. These spatialities are thus manifestations of the actors' relations with one another, enabling what happens within this space (Tamburelli, 2017). A selection of those spaces will serve as the Proto-Renaissance context wherein we will act (and question, in a later stadium, perspective's generative capacities and spatial understanding). The means by which we will operate towards this objective and within this given context is through analogue (perspectival) drawing experiments (see 'Method').

A first work that was selected from the Scrovegni Chapel, and on which we will focus throughout the rest of this paper is The Birth of the Virgin (Figure 2). This fresco is located in the topmost band, and measures 200cm by 185cm. The scene takes place in Anna's bedroom, a rather peculiar one-room-house, one side opened towards the onlookers in the chapel, but still feeling claustrophobic because it is packed with people. A lot is going on in here. On the foreground two of the midwives are sitting on the ground around a basin of water, having prepared the cloths and taking care of the infant Mary. Central we see Anna in the bed, reaching out to the nursemaids standing next to her to take over the newborn. At

the left, a similar gesture is taking place at the doorway where the bread is being handed from the outside to the inside. The Virgin is being depicted twice; different sequences in time happen at the same moment in the same room – events that in fact happen successively. This polyscenic character of the painting will be important when commencing the exploration, for we return to the narrative that is (re)presented in the story. The narrative is employed as motive, as launch to determine the station point and the following acts. The idea of coinciding time and place in this painting is being repeated in an analogue way in our intervention. How this notion of 'narrative as motive' was applied, will be explained in the following.

Figure 2. The Birth of the Virgin (1303-1305). Fresco by Giotto di Bondone

4 Method

In order to reconstruct this imagined space (or at least a first possible version of it), and to obtain a three-dimensional fictive field wherein we can exploratively test our assumptions, we needed to conduct a reversal of projection – retrieving a 3D reconstructed space from the 2D rendition. Our systematic device for this is to subject it to linear perspective. This compelling urge to rationalize the inconsistent is a human tendency (prompted by convention), which is also exampled by cartographers representing the world through/with a map (Besse, 2001), by similarly constructing a whole from a series of fragments. The world (or even a continent, a country, an area) is never to be seen or grasped in real life as it is represented on a map. In a comparable way is an experienced sight as well a composition of the different fragments that our moving eyes have crossed, and is a perspective drawing, just like a map, an artificial reconstruction of this elusive moment, an abstracted translation of a frozen moment in time. Applying (linear) perspective drawing in order to create a unified

and systematized depiction is an attempt to rationalize the ungraspable: ‘the reality’, a view, or in this case a Proto-Renaissance depiction that may be perceived as distorted. When constructing a linear perspective, everything is pivoting on the vanishing point in the image - and its correlated station point in space. So before the reversal of the projection (from 2D to 3D) can take place, it is necessary to determine the exact location of this vanishing point in the painting. When applying this reasoning on the Birth of the Virgin we can quickly find out that there are multiple – though unintended – vanishing points to detect (and thus multiple station points to be derived as well). The polyscenic character of the fresco, the combination of the three sequential actions happening at the same time in the same space, matches up with the threefoldness of the inwards movement that is guided by and goes through the three planes that stand perpendicular to the picture plane. From left to right we first pass the plane that is formed by the two columns, the second plane is the wall with the door, and eventually the inwards movement comes to a halt at the wall with the window. These three planes show, one after the other, slowly more narrowing openings, funnelling the penetrating action. From these three planes, (1) three vanishing points can be derived in the drawing (Figure 4) that imply (2) three station points in the space of the chapel. The movement along the wall from viewpoint to viewpoint corresponds with the inwards movement through these planes. After having determined the vanishing points and station points the intervention can proceed and (3) all the information will be projected on the picture plane, being an imaginative field but at the same time located in a physical whole (embedded in the wall of the chapel). The picture plane can be interpreted as a veil, as Alberti (1435) presented, that captures an image when it intersects the cone of sight. This intersection, the picture plane, coincides with the surface of the wall. With the basis set on the picture plane, (4) an assumption needs to be made according a particular proportion of choice (a hypothesis of an in-depth measure) which will influence the whole construction as a yardstick. For the three station points from left to right we have respectively assumed that the side balustrade has the same proportion as can be discerned in the frontally viewed railing, that the coffered ceiling is composed of squares and that the bed is standardly proportioned. Now that the construction is plotted on the picture plane, and the different yardsticks are defined, (5) the lines can start to penetrate the pictorial space and transform it to a space of action by shaping plans and sections. This is where the real shift from spatial suggestion to spatial occupation happens.
The station points, our positions we take in the narrative and in the plan, we actively and autonomously chose as draughts(wo)man/architect. But thereafter the rules of the technique are able to take (over) the lead in the process of formation as well. The sightlines, the projecting lines and the lines converging towards the vanishing point, are not just ours to trace, but are bound to the rules of linear perspective. Hence perspective has the potential to be not only a tool for 2D representation, but it could also be(come) a tool – or maybe better: a guiding principle – for three-dimensional spatial generation. The balance between the conducting role of the drawing mechanism opposed to the authority of the draughts(wo)man is yet to be examined more intensely in the course of this research project, but the initial exploration and findings are already presented here.

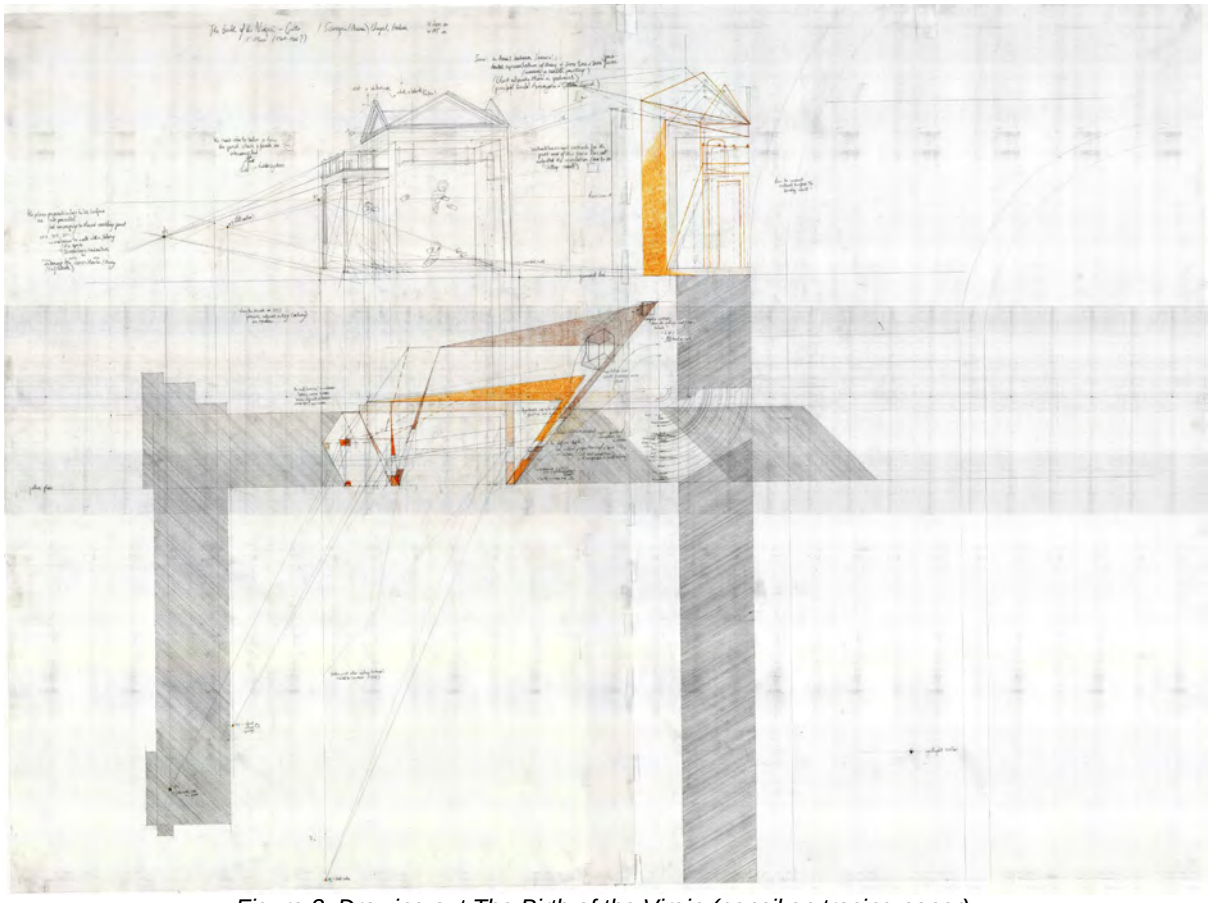

Figure 3. Drawing out The Birth of the Virgin (pencil on tracing paper).

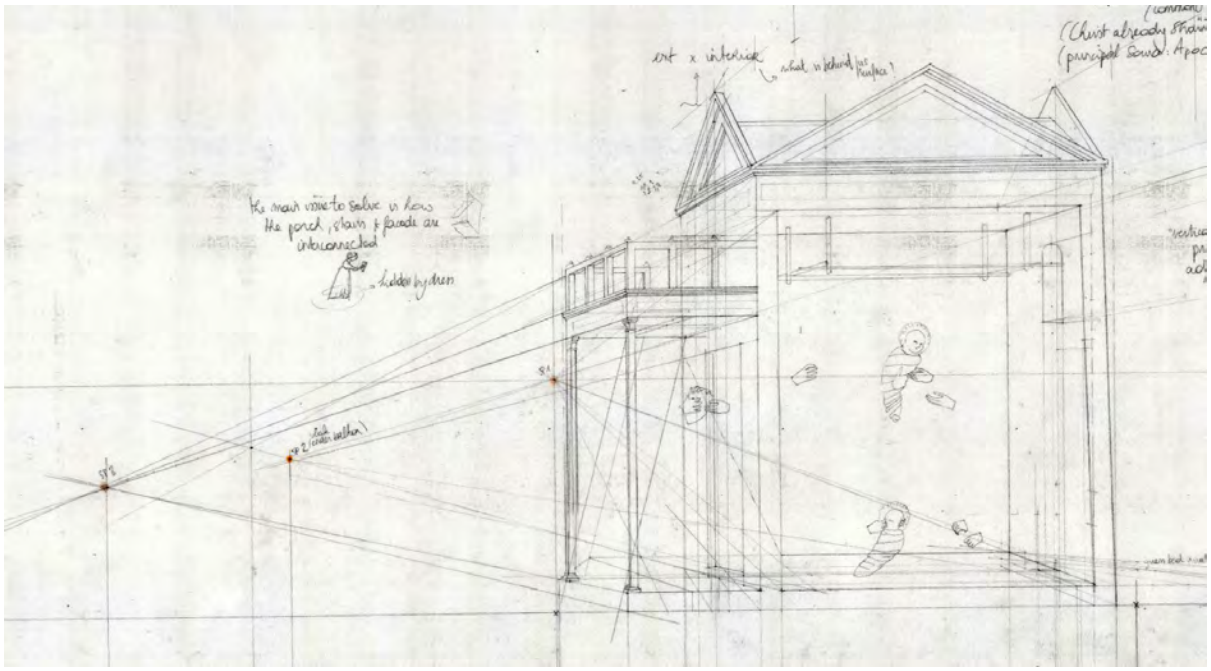

Figure 4. Detail of the drawing: three vanishing points derived from the three planes, perpendicular to the picture plane.

4.1 On The Act of Space-Making

Behind the picture plane, the space emerges line by line, unexpectedly. Affected by the guiding principle to engage the narrative of the painting as a motive for the intervention, this

results in an amalgam of projections (three layers, related to the three vanishing points, on top of each other) that suggests a coinciding of different moments in time (the same depiction seen from the three points of view) joined together in one new physical space. The drawing of this composite space, a new whole made out of three isolated gazes, is comparable to the chronophotography of Étienne-Jules Marey (1830-1904). The French physiologist exposed photosensitive paper in quick successions to a certain scene (a man walking, a pelican landing, a horse running…) and hence captured a movement in time joined in one photograph. This layered reconstruction is just a first in a series of continued derivations, converting a 3D back again into a 2D, into a 3D, into a 2D… Each stage in this iterative process establishes its own specific associative framework conditions, which leads to taking new stances within changed narratives, providing evolving contexts to empirically rerun the procedure of drawing and dwelling (Critical Sequential Drawing or CSD (Van Den Berghe, Sanders and Luyten 2019)). As draughts(wo)man there was no intention to obtain a specific space, but (s)he sees it happen as it comes about, as it literally takes place. The draughts(wo)man is actor, critical observer, sequential re-actor based on previous critical observations that generate improvement of action, hence CSD. This aspect, as described above, we refer to as the Act of Space-Making, handling with perspective as a geometrical construct and aiming for a shift in use: namely developing an innovative process in the making of space by probing the potential of perspective.

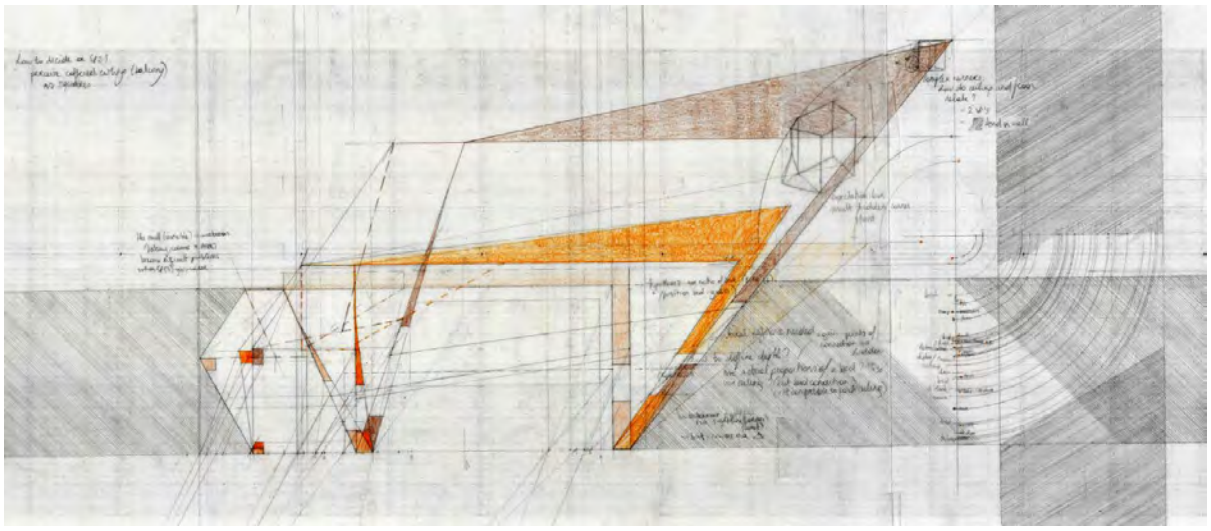

Figure 5. Detail of the drawing: the amalgam of three layered projections in plan. Each layer (pink, orange, brown) is derived from a different point of view.

4.2 On The Act of Looking

The other act we are engaged with is the Act of Looking, and here we deal with perspective as being a cultural construct: a dominant Western paradigm, a way of perceiving and understanding space that we have come to see as convention. On this level we intend a mental shift: we aim for an awareness about this dogma and critically questioning it. The Act of Looking is concerned with one's spatial expectations and perception, and how reality is not always instantly reconcilable with appearance. The three-dimensionalised depicted architecture provides a fictive space that can serve as a looking machine, in which the spatial explorations result in an experience that doesn't meet visual expectations and where the estranging elements impact the space and create non-conventional tensions. At first glance one perceives a certain harmony for it seems that what one sees is what one will get. But when relocating, tensions emerge and expectations need to be adjusted to the new

‘reality’. Gibson (1950) made a distinction between the visual field and the visual world. The first is a kind of perception that one observes as a picture, a fixated screen composed out of projected shapes. The visual world requires however a different way of seeing and relates to a three-dimensional sensation that consists of depth shapes. Within Anna’s house the disorientating game of shifting viewpoints in this reconstructed looking machine (harmoniously constructed station points that display projected shapes (visual field) vs. all the other points of view that bring about depth shapes(visual world)) can slow down the onlooker, inciting him to look with an improved awareness. The distortion, firstly appearing to be logical, now causes to doubt, and attempting to comprehend it will cause to waver. Tricked by perception, an awareness and a questing stance towards our looking and spatial understanding is instigated in an attempt to comprehend the destabilizing provocation and the relationship between the visual registration and the body that has its own specific position and orientation in space. Perception, and vision being regarded as self-evident, are questioned in a space that is unconventionally composed, breaking free from orthogonality. The new spatialities that we – literally – draw out from Giotto’s fresco are not designed as mere (re)constructions, but these extractions are a fictive context that allows for the exploration of one’s own looking while simultaneously exploring the space itself. The goal is not to obtain this object of perception as such, but to operate within it to look into one’s very perception.

The fiction and the ambiguity, inherent to the original image, make for flexible spaces that present a fluid context or situation, which is a fertile ground for exploration and potentially subsequential innovation. As different rules and dynamics are at play, where hypotheses are acknowledged and confusion is condoned, creative insights may be developed. The ‘faults’ and paradoxes serve as trigger and eye-opener, for they are the cracks that open up to the network of possible places.

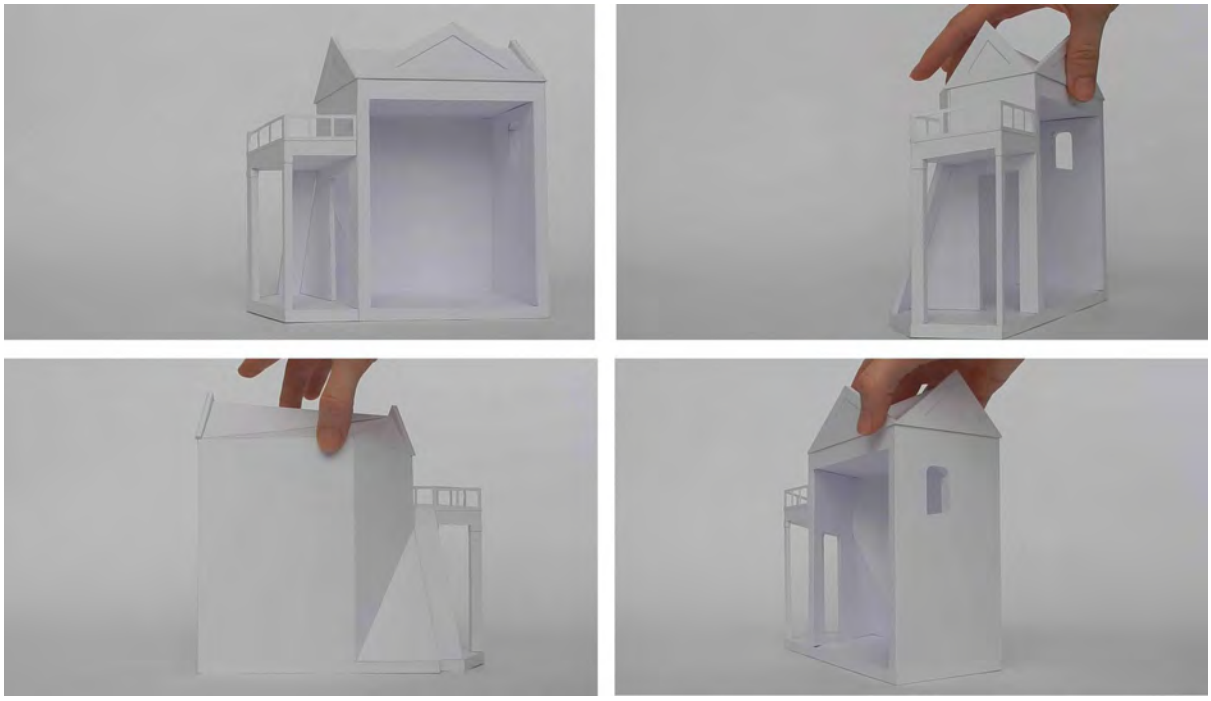

Figure 6. Stills from a movie that shows the mise-en-scene of the model that was constructed based on the pink layer. Being a three-dimensionalized object, the distortions become visible.

5 ‘New Space’

The research on the Act of Looking and the Act of Space-Making happens through (analogue) drawing, in combination with self-reflection. Drawing is employed in this research as an interface between thoughts and forms, between mind and hand, and serves both as verb (drawing as tool) as well as noun (the drawing as site). The initial establishment of the space, as well as comprehending and sensing it, happens through the physicality of (embodied) drawing, bridging the distance between the image and the onlooker. Drawing out the pictorial depth dissolves the picture plane – which separates the onlooker from the depicted space – and opens up the detached space of representation to become an experienced space of action. The involvement of the drawing is indispensable, for these kind of spaces are only accessible through/in the image. Christopher Frayling (1993) utilizes the word *imagineer* for the kind of researcher who explores and interprets intuitively the possibilities of an image. As an imagineer, an archeologist of images, we address the drawing as a device to unlock the three-dimensional potential of linear perspective and try to grasp our way of looking while drawing out an entrance to a multitude of possible spatialities behind the fresco of The Birth of the Virgin.

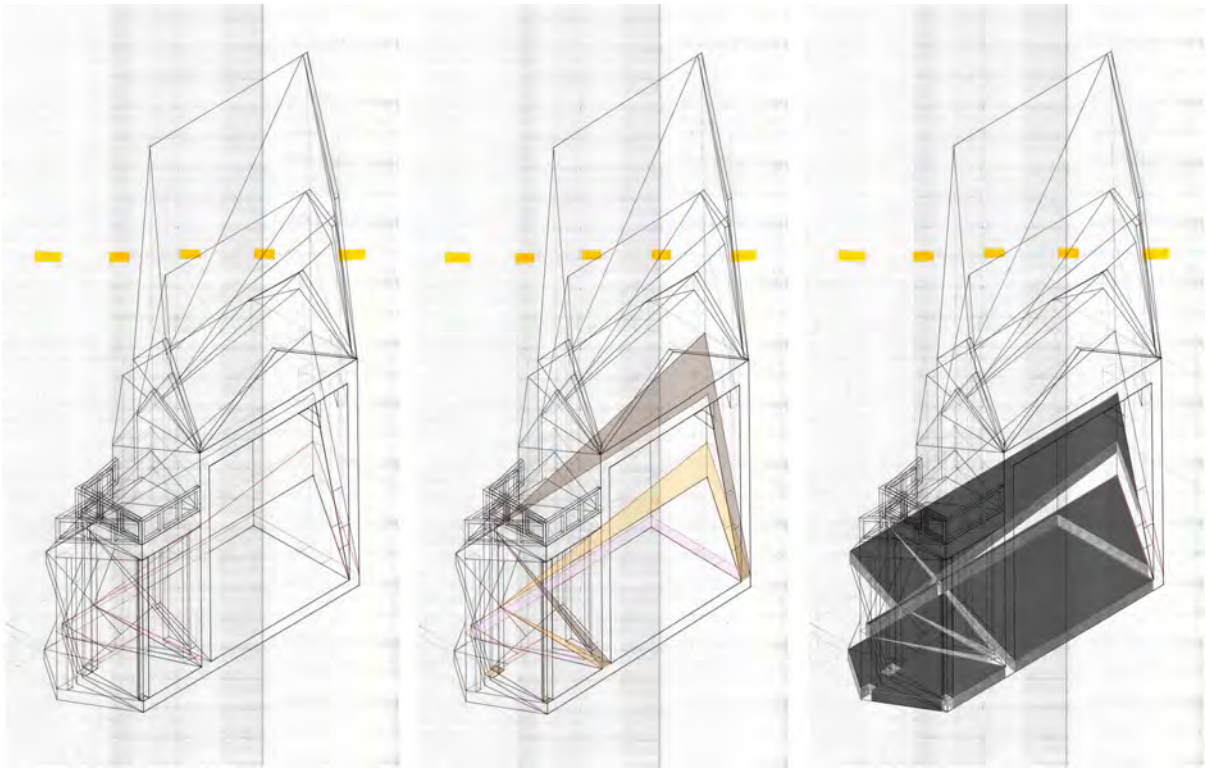

Figure 7. Isometric drawings of ‘the new spatiality’, or, the composite space of Anna’s room. The first drawing shows the three merged layers. In the middle, the contours of the three layers are highlighted (pink, orange, brown). The third drawing emphasizes the in-between-space.

With the new spatiality, in this case the composite space drawn out of Anna’s house (Figure 7),, we defy the resistance linear perspective has encountered since its downturn from the end of the 19th century onwards. Due to this transformation of ‘period eye’ there was no longer the same necessity for linear perspective. Paul Cézanne, playing a leading role in the breaking with this pictorial agreement, and at a later stage followed by the Cubists in the 20th century, renounced linear perspective for representing a too distant and lifeless abstracted version of reality, recurring to one immobile eye. In Merleau-Ponty’s analysis on Cézanne, he described perspective as tending to erase the physicality of perceptual experience

(Merleau-Ponty in Smith, 2013). Instead of limiting himself to scientific perspective, Cézanne chose a *lived perspective*: “a view from everywhere” (Smith, 2013). In a similar way the Cubists renounced linear perspective for the visible is “the totality of views taken from points all round the object” (Berger, 2008). Notwithstanding our application of a system (linear perspective) that had been dismissed by these modernists in their search for dynamism, we do feel related to them, for the new composite space (the amalgam of 3 possible reconstructions) is no mere frozen abstraction but demonstrates movement, intern fluctuation and elapsing of time as well. It tends to be an inviting and evocative (re)presentation that implies dynamism by means of a layered composition (a new spatial synthesis formed by combining disparate gazes), and manifests an instability that activates the onlooker. Analogue to Cézanne, offering with his lived perspective a composition of virtual movement around the object of perception (Smith, 2013), we present here a polyscenographic representation: a conformed image that suggests in its own way new temporal dimensions that are produced by multiple and virtual relocations. By combining the renounced scientific systematics and the searched for (virtual) dynamism, we build bridges where rejection had created a wide gap. We touch upon the critiques of those who disagree with Renaissance perspective, by transferring the original polyscenic painting, displaying a continuous narrative, into a polyscenographic drawing, which is linked to the chronophotographs of Marey (or for that matter cubist paintings by Picasso), and which constitutes the exclusive access to a new spatiality: a space that is not a frozen construction to look at from upfront, but a playground that invites the onlooker to come in. The depiction incorporates time and movement in itself, but it also contains the incentive for the onlooker to move (trough time).

The vivid and compliant environment that the fictive field offers for stretching its outlines while exploring the mechanism of perspective, demonstrates on the one hand the potential of perspective as a tool when it breaks with the conventionally associated rigidity and how it in doing so can question perception. On the other hand it indicates the unforeseeable and promising multitude of spaces that is possibly hiding behind Giotto’s wall, which we might unveil bit by bit by a continuous interplay of drawing (out) and looking/reflecting in our ongoing process of CSD. On this matter we have literally just started to scratch the surface.

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COMMUNICATING THE RELATIONSHIP BETWEEN DESIGN AND BUSINESS HAS LONG BEEN A CHALLENGE FOR DESIGN. WHILE DESIGN IS RECOGNISED AS A DRIVER FOR INNOVATION, DESIGN HAS LONG BEEN SEEN AS A COST RATHER THAN AN INVESTMENT. HOW CAN DESIGN BE EFFECTIVELY MANAGED TO MAXIMISE ITS ECONOMIC VALUE? WHAT EVIDENCE IS NEEDED TO JUSTIFY THE PLACE OF DESIGN AT THE BOARD LEVEL? HOW WILL NEW MODELS OF DESIGN SHAPE INNOVATION THINKING?

VALUE

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A study on task analysis for development of air traffic control system

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Air Traffic control tasks are very complex and hard to understand for task investigators and analysts. It is expected to improve task analysis method or technique for acquiring specific task contents. In this paper, we proposed the improved method and a case study of task analysis for air traffic control. The task analysis method of the air traffic control uses the visualization sheet of the task which displays the screen of the radar display. Analysis of this task analyzes ATC tasks based on the task visualization sheet.

Keywords: User Interface Design; Human-Centered Design; Air Traffic Control System

1 Introduction

The air traffic control is a task performed by air traffic controllers for supporting aircrafts from the ground so that they can be navigated safely from landing to take-off. The air traffic control system used for air traffic control gives directions at any time to controllers utilizing various information such as congestion conditions and meteorological conditions in the routes, so as to secure safety distance of aircrafts, based on current positions and altitudes of the aircrafts, as well as flight plans including departure place and destination. This task is called air-traffic control. Among the air-traffic control works, tasks called air route traffic control are usually performed by 2 persons, one person is the radar air traffic controller and the other one is the coordinator. The radar air traffic controller monitors safety distance of aircrafts based on radar information and gives directions such as location or altitude of the aircrafts in communication with pilots. The coordinator contacts controllers in charge of other airspace and coordinates the traffic referring to flight information of the aircrafts other than radar information (information required for aviation is inscribed) so that aircrafts can be navigated smoothly. The radar air traffic controller monitors all aircrafts flying in the airspace that they are in charge of and gives directions at need. The radar air traffic controller controls more than 20 aircrafts maximum at the same time. Although it is expected that the tasks of controllers will be even heavier in the future, smooth and safe navigation must be continuously secured. Therefore, it is important to obtain user interface which is easy for controllers to use for securing safe and smooth navigation. As one of the methods to consider usability of user interface of an air control system used for air traffic control tasks with high specialty, utilization of human-centered designing is expected. The process of human-centered designing is roughly divided into "Grasp and express of usage status",

"Express of requirements of user and organization", "Preparation of solution by design" and "Evaluation of design for requirements". For "Grasp and express of usage status", consideration of a system desirable for users will be an important factor. There are qualitative and quantitative method for grasping what purpose the target users have and how they use the system in usage status. The quantitative method includes "questionnaire survey", "interview survey" and so on. When there are some kind of assumptions, question items that focus on them are prepared to verify the assumptions. There exist various methods such as "observational research" or "task analysis". In "task analysis", ergonomists, designers, operators and evaluators describe interaction between machine and persons and between persons, and use task analysis to evaluate them in some cases. "Task" is "an act to be performed to achieve goal". One task is comprised of plural tasks, and those subdivided into concrete acts are "subtasks" (Figure 1). The task analysis method consists of 2 phases, "description of task" and "analysis of task" (Figure 2) [1].

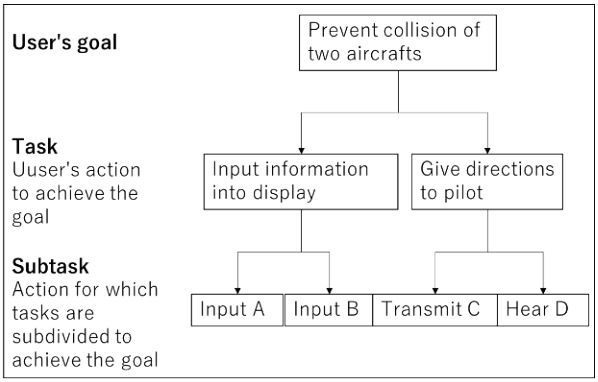

Figure 1 Configuration of task

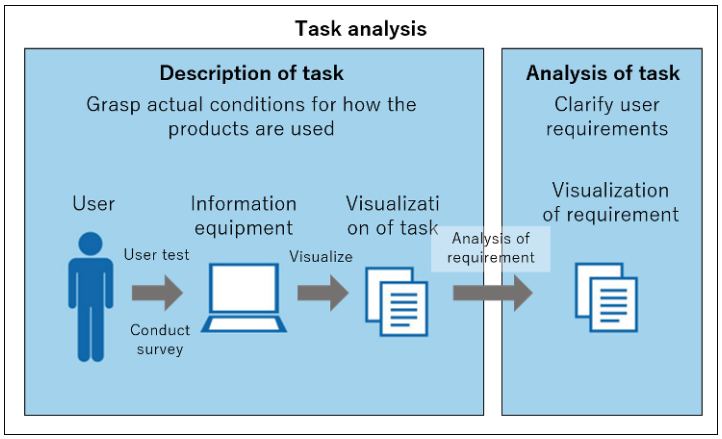

Figure 2 Phase of task analysis

"Description of task" is to describe a series of actions and works of a user as shown above, and "Analysis of task" is to clarify user requirements in actions and works subdivided individually. There are a number of case examples for consumer devices in task analysis. One of the main reasons is that designers have experience in using the target device in their daily life and feel easy to analyze the user interface, we presume. However, in the case that the analysis subject is a device specialized for the task, there are little number of case examples of task analyses in specialized tasks, and therefore designers have less chance to use such a device specialized for the task and can hardly obtain experience of its use. Above all, it is difficult for a designer to grasp the task of air-traffic control works and

therefore the number of case examples of the task analyses is particularly small. Therefore, it is desired to improve the task analysis method so that designers can feel easier to grasp the task of air-traffic control works.

2 Purpose of this study

As one of the task analysis, there conventionally exists "sequential task analysis method". The sequential task analysis is a method that subdivides one task into several subtasks and analyzes them in the user interface of the device. Moreover, it subdivides a task into subtasks and arrange them from the viewpoint of "input" to information equipment by a user and "output" of input information for the user. There are various practice case examples of the sequential task analysis for consumer devices, such as "Work on usability in the field of home electric appliances", "Usability evaluation of voice interaction function in video reproduction operation of TV program", "Proposal of service presentation system based on the behavior forecast of user utilizing task model" and so on.

However, there are only few practice case examples of the task analysis in commercial devices that require specialized information. The reason why there have been only few case examples is that it is difficult to extract problems in a specialized commercial device in surveying tasks. Moreover, difference occurs in recognition of a designer and users or problem solving itself is not relatively easy in some cases. In particular, it is not easy to use "the sequential task analysis method" for devices that require much specialized information such as air traffic control system used in air-traffic control works, we presume. In this study, we aim at improving the Method of describing the task of sequential task analysis of the air-traffic control works can be grasped easily and task analysis of the air-traffic control works can be performed easily for air-traffic control works, even when a designer does not have knowledge on air-traffic control works.

3 Method

In this study, we first extract problems on sequential task analysis in air-traffic control work, improve the sequential task analysis method. In this report, Chapter 4 describes the verification of the sequential task analysis in air-traffic control works and problem extraction for the method of sequential task analysis in air-traffic control works. Chapters 5, 6 and 7 describes how to the method of the improved sequential task analysis and the verification of the improved sequential task analysis in an air traffic control system. Chapter 8 summarizes the entire study.

4 Problem extraction for the method of sequential task analysis in air-traffic control works

This chapter describes "observational research of air-traffic control works", "verification of task visualization", " task analysis" and "problems when using the sequential task analysis in air-traffic control works".

4.1 Observational research of air-traffic control works

In observational research of air-traffic control works, the task data of air-traffic control works are collected so as to verify the sequential task analysis of the air-traffic control works. The observational research of air-traffic control tasks was performed with cooperation from Tokyo Air Traffic Control Center (Tokorozawa). The observational research was performed with the

control system "ECSS", which is an air traffic control simulator. The outline of the observational research is below. The time and date of the research was March 15, 2012. The observation was performed in Tokyo Air Traffic Control Center (Tokorozawa). The time required for the observational research was 20 minutes for instruments preparation, 15 minutes for instruments check and 30 minutes for observation. Control works are usually performed based on 30-60-minute shifts. Therefore the observation time was 30 minutes, which corresponds to the time for one work. The participants are 2 simulator operators (the radar air traffic controller and the coordinator) + 1 controller (in charge of pilots), 4 members who have knowledge of basic air-traffic control works (understand functions of the air traffic control system and conversation between controllers on work) and 1 member who is qualified as a controller. Devices used for the observational research are four video cameras to record the display of the radar air traffic controller, the radar air traffic controller operation (display, TID (Touch Input Display: information input with touch panel display) and angles at which keyboards are entered), display of the coordinator, operation objects for the coordinator (display, TID and angles at which keyboards are entered) and voice recorder (the radar air traffic controller, the coordinator and pilot), which were placed as shown in Figure 3.

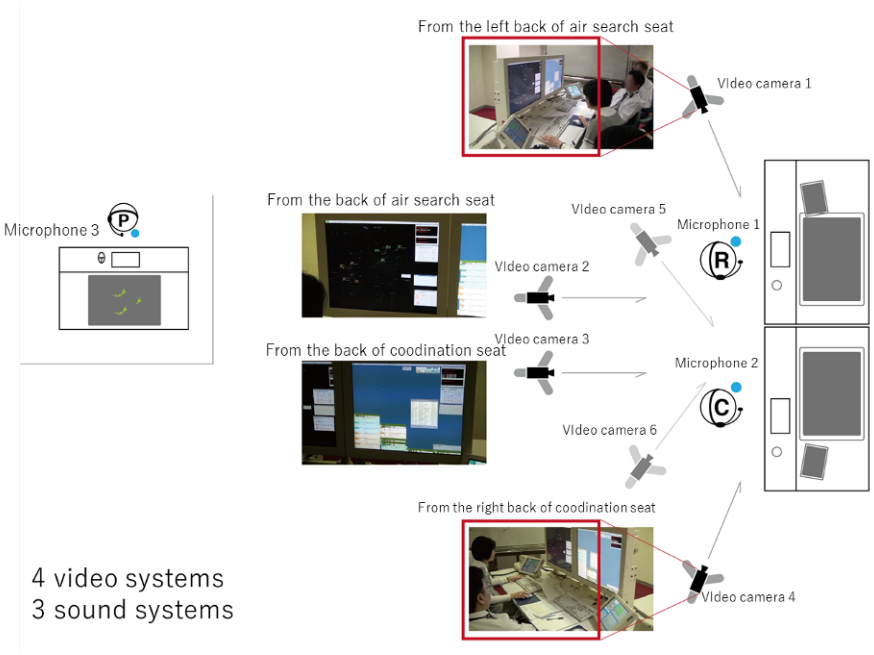

Figure 3 Arrangement of shooting device at the time of observational research

4.2 Verification of task visualization

The tasks are described and arranged by the sequential task analysis method so as to extract problems in task visualization in air-traffic control works. Data used for verification of task visualization were acquired in Chiba Institute of Technology on April 20, 2012. The time required for acquisition was 4 hours. Participants were 4 staff members having basic knowledge of air-traffic control works, and 1 member who was qualified as a controller. The items to describe the tasks were arranged as "communication with aircraft", "directions task in the communication", "duty hour", "aircraft controlled", "operation content" and "conversation with pilot" for the purpose of grasping what directions were given to which aircraft (Figure 4).

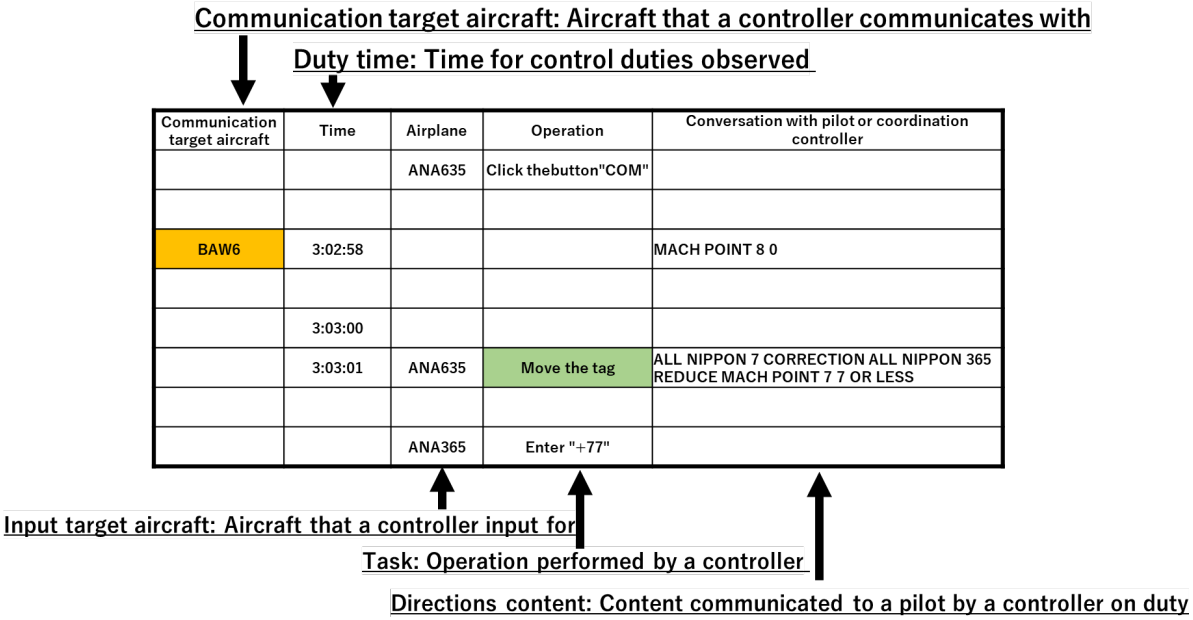

Figure 4 Task visualization by the sequential task analysis

Moreover, for the task visualization, the vertical axis was set as a temporal axis to make it easy to grasp control works, and all tasks observed during 30 minutes were described with the horizontal axis as task items to be described.

4.3 Task analysis

To find out problems of sequential task analysis for air-traffic control works again, the task analysis was performed based on the sequential task analysis. Outline of the task analysis is shown below. The task analysis was performed in Chiba Institute of Technology on April 20, 2012. The time required to analyze the task was 2 hours (one hour for confirmation of the video observed + 1 hour for confirmation of the task visualization). Participants were 4 staff members having basic knowledge of air-traffic control works (understand functions of the air traffic control system and conversation between the air traffic controllers on work), and 1 member who was qualified as a controller. The items to be recorded in the sheet for the task analysis are "Scenes" where the tasks were performed and "Characteristics of control work and request from controllers". The above items were selected for the purpose of making it easy to grasp contents of the tasks and when they were performed, based on characteristics of air-traffic control from the described air-traffic control tasks. As a result of the task analysis, three characteristics of the air-traffic control works were extracted (Table 1). Contents of the three extracted characteristics of the air-traffic control works were analyzed from usage frequency of the functions that air search used the air traffic control system. Moreover, requests from the controllers were extracted.

Table 1 Result of task analysis by the sequential task analysis

Scene			Characteristics of control work
Work hour	Aircraft	Task	
03:00;30～03:00;40	-	Display MAP3	The controller confirms the map display first it but does not almost use it after that.
03:02;18～03:02;28	JAL2201	Input MAC number	The controller often input mac number rather than header and speed.
03:06;00～03:06;07	-	Switch display by DCP8	The controller often confirmed fix before giving the direction of Direct .

4.4 Problems in the case that the sequential task analysis in air-traffic control works

Task observation, description analysis and task analysis were performed based on the sequential task analysis method in air-traffic control works. The result revealed that there were 2 major problems as below on the task visualization in the sequential task analysis. The first problem (Problem 1) is that "It is hard for a designer is grasp requests from controllers, who are users", in task visualization again. Technical terms are used in air-traffic control works, and many of the functions of the air traffic control are to be used in specialized information equipment. Therefore, it has been revealed that in the case that a designer does not have knowledge of air-traffic control, even if the tasks performed by a controller are summarized in character information, it is difficult to extract requests from controllers though some characteristics of a controller for air search are expressed. The second problem (Problem 2) is that "It is unclear in the task analysis where on the screen of the air traffic control system the tasks were performed by the controller". In the case that a designer did not have knowledge of air-traffic control works, the flow of the tasks were grasped on the temporal axis by confirming the tasks performed by the controller in time series, while on the other hand it was hard to grasp relationship between controller's tasks and the video. One of the reasons is that since the controller's tasks were described in time series and user interface of the radar control system was confirmed with video, it was difficult to confirm air traffic control works connecting them, we presume.

5 Improvement of the method of sequential task for development of air traffic control system

This chapter describes the improved model sequential task analysis method for developing air traffic control system based on the problems on the sequential task analysis obtained in the preceding chapter.

- Step 1. The radar display sheet for the task visualization

The radar display is utilized for the task visualization. Background of the radar display is black. Therefore, background of the task visualization sheet is white so that tasks can be seen when they are written on the sheet. Moreover, airspace and routes displayed on the radar display are shown on the sheet (Figure 5).

Figure 5 Radar display sheet

- Step 2. Description of the trace of controller's operation

The trace of the cursor operated by the controller on the radar display of the control system is drawn on the sheet made at Step 1 for every minute. The trace of the operation is to be expressed with clear initial and end points (Figure 6).

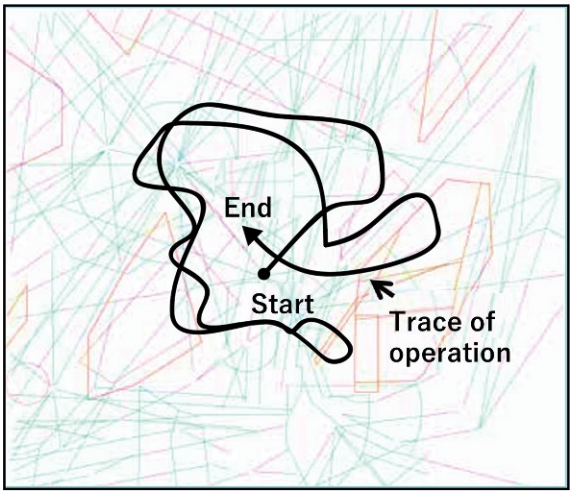

Figure 6 Radar display sheet on which trajectory of operation is drawn

- Step 3. Task visualization for air-traffic control works

The tasks of air-traffic control works are described on the radar display sheet made at Step 1 (Figure 7). For the tasks to be described, content of the task for one minute is written on one sheet. Contents for the task visualization are shown below.

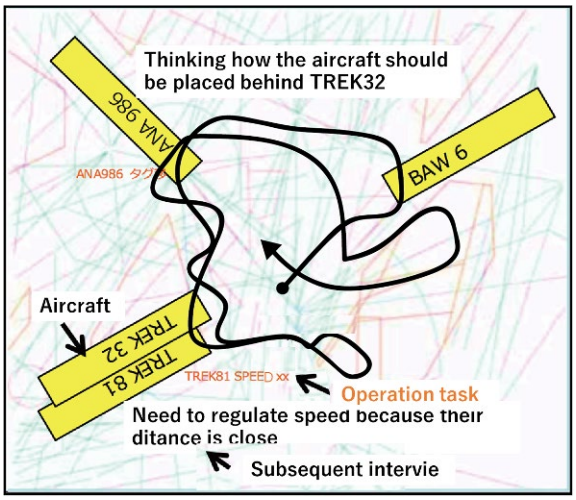

Figure 7 Radar display sheet on which began air-traffic control task is drawn

1. Display content

The aircrafts displayed on the radar control system are described with tags. The directions of aircrafts flying are made same as those shown on the radar display with reference to the video of the observational research. The aircrafts' names are shown on the tags.

2. Content of subsequent interview

The contents of the subsequent interview of controllers obtained by the observational research are described along the temporal axis of the trace of the controllers' operation.

3. Content of the operation task

Numerical information such as altitude or velocity of aircraft input by the controller input with a radar control system is described along the temporal axis.

The task visualization method was improved for the two problems shown in the preceding chapter as described below.

- Problem 1: It is hard for a designer is grasp requests from controllers, who are users
- Problem 2: It is not clear where on the display of the air traffic control system the controller's tasks were operated

As a method for solving Problem 1, trace of the controller's operation with the radar control system is described on the display of the radar control system. The intention of this method is that describing trace of controllers' operation has an advantage that a designer can visually see ideas of the controllers' directions, which makes it easy to grasp air-traffic control works. As a method for solving Problem 2, controllers' tasks are described on the display of the radar control system. The intention of this method is that a designer can easily connect controllers' tasks and the user interface. For such a reason, tasks are described on the sheet with the display of the radar control system on it. Moreover, the tasks are described with the trace of the controllers' operations, which is an improvement point of Problem 1, as an axis. Describing the task along the trace of operation allows to confirm tasks while following the trace of operation. Therefore, the intention is that it will become easy to grasp ideas of controllers' directions. The improvement of description of the two tasks mentioned above will make it easier for a designer to grasp air-traffic control works. Therefore, we supposed that combining the improved task visualization and task analysis of the sequential task analysis would make the improved task analysis in the air traffic control system development effective for understanding air-traffic control works.

6 Verification of the improved sequential task analysis for air traffic control system development

Our idea was that the improvement of the description of two tasks mentioned above would make it easy for a designer for to grasp air-traffic control works. Therefore, we supposed that combining the improved task visualization and task analysis of the sequential task analysis will make the improved sequential task analysis in the air traffic control system development effective for understanding air-traffic control works.

6.1 Verification of the improved task visualization

Outline of verification of the improved task visualization. Verification was performed in Electronic Navigation Research Institute on August 24, 2012. The time required to describe in the improved task visualization was 6 hours. Participants were 2 staff members having basic knowledge of air-traffic control works (understand functions of the air traffic control table and conversation between controllers on work), and 1 member who was qualified as a controller. The instruments used for the verification were writing implements, video of air-traffic control works, tags and radar display sheets for describing tasks (30 pieces of A4 paper). The verification process is described below.

- Process 1: Preparation of sheet for describing tasks

Describe basic information (including airspace and routes) displayed on the radar control system in the sheets for describing tasks.

- Process 2: Confirmation of the video of air-traffic control works

Perform observational research based on the video data of approximately 30 minutes obtained by the observational research of the air-traffic control works that were used for the verification of the sequential task analysis.

- Process 3: Description of the task of air-traffic control works

Describe "content of the display", "operation task", "subsequent interview content", and "trace of the user operation" on one sheet for every minute (Figure 8).

The improved task visualization method allowed to describe all air-traffic control tasks of the observational research of 30 minutes.

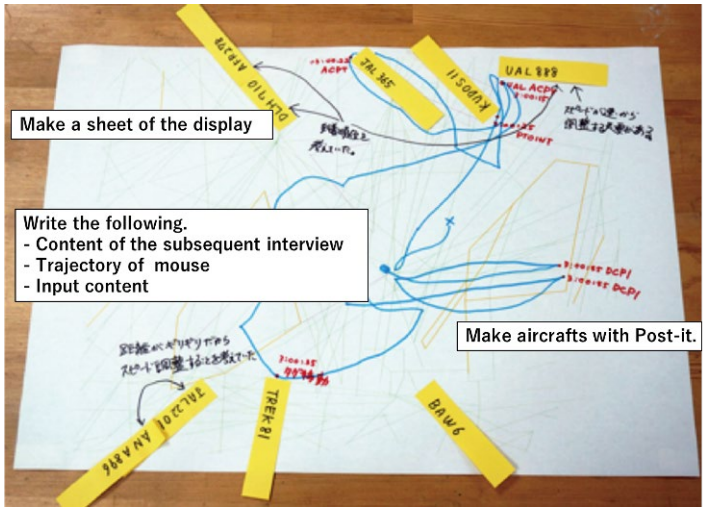

Figure 8 task visualization by the improved task analysis for air traffic control system development

6.2 Task analysis

Outline of the task analysis is described below. The task analysis was performed in Electronic Navigation Research Institute on August 24, 2012. The time required to analyze the task was 2 hours (1 hour for confirmation of the video observed + 1 hour for confirmation of the task visualization). Participants were 2 staff members having basic knowledge of air-traffic control works (understand functions of the air traffic control table and conversation between controllers on duty), and 1 member who was qualified as a controller. Instruments used for the task analysis were PC1 to confirm video of the controllers' tasks obtained by observational research, PC1 to describe tasks and sheets to analyze the tasks. Items of the tasks were "Scene" and "Characteristic of air-traffic control works" which were performed in the same way as the sequential task analysis. As a result of the task analysis, 20 characteristics of air-traffic control works were extracted (Table 2). Moreover, the results of the improved task analysis revealed that control works were analyzed together with reasons for the tasks such as "Influence on aircrafts behind" and "Analysis on priority of aircrafts to be converged" for the tasks performed by controllers.

Table 2 Result of task analysis by the improved task analysis

Scene			Characteristics of control work
Work hour	Aircraft	Task	
03:00;30～03:00;40	-	Display MAP3	Need to arrange the operation by predicting arrival orders of AFR278,DLH710 and UAL888 separating operation display and arrival prediction
03:02;18～03:02;28	JAL2201	Input MAC number	The controller confirms the map display first it but does not almost use it after that
03:00;30～03:00;40	-	Display MAP3	When the distance between two aircrafts is close, the operation will be smoother by giving directions to the preceding one.
03:03;01～03:03;09	ANA365	Input MAC number	When confirming AAR102 and KUDOS11, other directions are given more easily by deciding clear directions when dodging by altitude directions first.
03:04;56～03:05;03	ADO45	Communication (direction)	Directions are limited by restricted area.
03:06;51～03:07;03	JAL2201	Communication (altitude)	Confirm fix after the aircraft enters the restricted area to some extent.
03:07;58～03:08;01	ADO45	Move tag	It is difficult to give new directions to the following aircraft unless directions to the preceding aircraft is completed.
03:08;58～03:09;00	BAW6	Communication (altitude)	When status changes under the influence of wind, the priority of the aircrafts changes.
03:09;25～03:09;26	UAL888	Communication (altitude)	Lowering speed causes risks to the following aircraft.
03:09;50～03:10;06	AFR278	ACPT	Overall directions are influenced by changed separation.
03:11;02～03:11;07	BAW6	Communication (altitude)	Directions are limited by restricted area.
03:12;14～03:12;15	KUDOS11	Communication (altitude)	Need to think about structure of future directions for operating the aircrafts of the same destination.
03:13;54～03:14;00	BAW6	Move tag	The controller wants to transfer under a sufficiently safe a situation though it's not allowed to do so.
03:14;59～03:15;02	IBEX3147	Communication (ACPT)	The following aircrafts are influenced by the undecided orders of them.
03:15;58～03:16;01	IBEX3147	Input altitude	The controller does not want to change flight plan
03:18;02～03:18;04	UAL888	Input altitude	The controller wants get the aircraft back to the original route and reduce directions.
03:19;01～03:19;02	ANA748	Communication (altitude)	Make aircrafts detour to make it converge with others.
03:19;57～03:20;02	IBEX3147	Communication (altitude)	Lowering speed causes risks to the following aircraft.
03:20;58～03:20;59	AAR102	Communication (altitude)	Trying to make aircrafts cross giving different altitudes.
03:22;39～03:22;42	ANA50	Communication (altitude)	Maintain separation by uniformizing speed.

7 Summary of the improved sequential task analysis for traffic control system development

This chapter describes characteristics of the improved sequential task analysis method for air traffic control system development from the viewpoint of "time required of verification", "the number of characteristics of the extracted air-traffic control works" and "content of characteristics of the extracted air-traffic control works". Verification of the sequential task analysis was completed in 4 hours. On the other hand, verification of the improved sequential task analysis for air traffic control system development required 6 hours. The result revealed that the improved model sequential task analysis for air traffic control system development took longer by 2 hours than the sequential task analysis. Now, the number of characteristics of the air-traffic control works extracted from the analysis is discussed. Verification of the sequential task analysis extracted three characteristics of the air-traffic control works. On the other hand, the improved sequential task analysis for air traffic control system development extracted 20 characteristics of the air-traffic control works. The reason why 20 characteristics were extracted is that it became easier for a designer who does not have specialized knowledge to grasp the works by confirming tasks on figures, we reckon. Next, details of contents of the characteristics of the extracted air-traffic control works are discussed. The sequential task analysis has a characteristic to analyze the works based on controllers' usage frequency of functions of the air traffic control system while the improved task analysis has a characteristic to analyze the works based on the controllers' intentions for operation of the air traffic control system. These analyses are described with examples below. As a verification result of the sequential task analysis, a number of problems on

usage frequency of functions of the radar control system such as "The controller uses the map display change function at the time of the initial setting. However, it is always displayed even though the controller does not almost use it after the initial setting." were extracted. In contrast, as a verification result of the improved task analysis for air-traffic control works, characteristics of what the controller minded for the later direction such as "Because the aircraft AAR102 which entered the airspace was going to cross KUDOS11 later, the controller frequently checked their positions by mouse." were extracted (Table 3). The above results revealed that superficial characteristics such as the number of times of operations are easily seen in the sequential task analysis while the improved task analysis realizes not only the superficial analysis of the tasks performed but also task analysis with better understanding on works such as why the controller performed the operation.

Table 3 Comparison of task analysis result

Scene			Task analysis results	
Duty hour	Aircraft	Task	Characteristics extracted from the sequential task analysis	Characteristic extracted from the improved model task analysis
03:00;30～03:00;40	-	Display MAP3	The controller confirms the map display first it but does not almost use it after that	The controller confirms the map display first it but does not almost use it after that
03:00;40～03:00;45	-	Cancel MAP3 display		
03:00;45～03:01;04	BAW6	Move tag		
03:01;04～03:01;33	TREK81	ACPT		
03:01;33～03:01;36	TREK81	Communication (ACPT)		
03:01;36～03:01;41	TREK81	Communication (altitude maintenance)		
03:01;41～03:01;50	BAW6	Move tag		
03:01;50～03:02;05	JAL2201	ACPT		
03:02;05～03:02;07	JAL2201	Communication (ACPT)		
03:02;07～03:02;11	JAL2201	Communication (velocity)		
03:02;11～03:02;14	JAL2201	COM		
03:02;14～03:02;18	JAL2201	Move tag		
03:02;18～03:02;28	JAL2201	Input MAC number	Input mac number more often than header and speed.	When the distance between two aircrafts is close, the operation will be smoother by giving directions to the preceding one.
03:02;28～03:02;31	TREK81	Move tag		
03:02;31～03:02;41	ANA365	ACPT		
03:02;41～03:02;46	ANA748	Move tag		
03:02;46～03:02;48	AAR102	Move tag		
03:02;48～03:02;50	ANA036	Communication (ACPT)		
03:02;50～03:02;54	SKY703	Move tag		
03:02;54～03:02;55	ANA036	Communication (velocity)		
03:02;55～03:02;56	ANA365	COM		
03:02;56～03:03;01	ANA365	Move tag		
03:03;01～03:03;09	ANA365	Input MAC number		When confirming AAR102 and KUDOS11, other directions are given more easily by deciding clear directions when dodging by altitude directions first.
		Communication (velocity)		
03:03;09～03:03;14	ADO45	Move tag		

8 Conclusion

This paper described the improved sequential task analysis for air traffic control system development for the purpose of improving the sequential task analysis method to make it easier to grasp tasks of the air-traffic control works in the case that a designer does not have knowledge of air-traffic control works. We extract problems on the sequential task analysis in air-traffic control works from the sequential task analysis, and proposed the improved sequential task analysis for air traffic control system development for which the improved task visualization and the task analysis of the sequential task analysis were combined. Moreover, we verified if the improved sequential task analysis for air traffic control system development is effective for a designer who does not have knowledge of air traffic control works. The result revealed that the improved sequential task analysis for air traffic control system development was successfully improved so as to make it easier to grasp air-traffic control works than the sequential task analysis. However, since the time required for the task analysis is long, it is necessary to improve it so as to shorten the time required for the improved sequential task visualization. In the future, we think that it is necessary to examine

the idea of the user interface of the air traffic control system and verify the effectiveness of the idea in order to verify whether the features of the extracted air traffic control work are effective in the development of the air traffic control system. Also, we want to be able to improve the sequential task analysis so that it can be generally generic in product development for the business.

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A Theoretical Exploration to Achieve Porter and Kramer's Shared Value Creation in the Perspectives of Design

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The design has received a spotlight as a competitive strategy for businesses. However, despite the widely accepted impact of design, the value of design is often implicit and unexpressed yet. This paper aims to communicate the qualitative value of design in the business context, especially when a business seeks to find a win-win solution, called a 'shared value,' that aims to fulfil both interests of business and society. The paper begins with a review of six international design awards' judging criteria to identify the qualitative components of a good design. The components include form, function, innovation, society, and business. Three components, form, function, and innovation are found the unique elements; therefore, they are further explored through the review of scholarly work. The relationship between form and function and theories on innovation that creates qualitative value are investigated. Finally, the theoretical review leads to the conclusion that all five components have to be considered jointly as a system in order to create shared value that ignites innovation for growth and that enables an optimistic shift from the current capitalist system and stagnation.

Keywords: shared value; competitive strategy; design strategy; qualitative value

1 Introduction

In 2011, business professors Michael Porter and Mark Kramer introduced 'shared value' to the world as a new competitive strategy for strengthening social responsibility in the conventional capitalist system. At the heart of the concept, shared value aims for a win-win strategy (De los Reyes Jr., Scholz, & Smith, 2017) that can achieve benefits for both society and business. Many advocates support the concept and widely practice shared value, especially for its cost efficiency in creating strategic social responsibility as an inherent part of the corporate strategy (Lee, Moon, Cho, Kang, & Jeong, 2014). Shared value is also widely accepted for its purpose in long-term sustainability (Pirson, 2012). Moreover, many supporters admire shared value's capability to generate fundamental innovation for economic growth and competitiveness (Michelini, 2012; Spitzech & Chapman, 2012).

Despite its immediate success relating to its idealistic purpose, shared value has been criticized for its viability to realize the concept in real practice (Fürst, 2017). One reason for the sharp criticism is that reviewers have found shared value to be naïve (Crane, Palazzo,

Spence, & Matten 2014) for achieving a long-lasting positive-sum (De Los Reyes et al., 2017) in real complex situations. When shared value aims for value creation beyond "trading-off" economic value for a social benefit or social goods for profit maximization, it is unrealistic that it will simultaneously achieve both in the capitalist system (Schramm, 2017).

To create a successful shared value, there is the obvious and critical issue of finding a solution in the midst of all the complex needs of society and business. Meanwhile, design has been known as a competitive strategy in business that has the ability to address and solve complex problems (Koo & Cooper, 2011; Liedka, 2015; Manzini, 2014; Thrope & Gamman, 2011). Such complex problems are often illustrated as "wicked" (Rittel & Weber, 1973) and "ill-structured" (Simon, 1973) problems. Design offers an efficient approach that is a new, unconventional learning process toward a solution (Dorst, 2006). Both design scholars and advocates of design in business management endorse the efficiency of adopting design to solve wicked problems (Buchanan, 1992; Heskett, 2016; Johansson-Sköldberg et al., 2013; Kolko, 2009; Liedka, 2018).

Buchanan, a design scholar, (1992) interpreted five characteristics of the wickedness of problems. He explained that there is often difficulty in proposing a universal and durable solution, inconceivability in defining problems' root causes, unpredictability in understanding the nature of a problem, incomparability to existing scenarios, and uncertainty in foreseeing the feasibility of a resolution. Describing such complexity concerning wicked problems, shared value seems to address a similar type of problems. For example, shared value creators seek to find new, breakthrough means of innovation that enable the creation of a competitive strategy for delivering economic growth and profit maximization to a firm. This is solely a complex enough task to deserve the label of a 'wicked problem.' In addition to this task, many companies experiencing economic stagnation and impasse because of the conventional means of innovation are not competitive enough to create any significant economic growth for the company (Rifkin, 2015). Therefore, companies start to find business opportunities from the context of society (Porter & Kramer, 2011), meaningful innovation (Brand & Rocchi, 2011; Den Ouden, 2012), social innovation (Manzini, 2013), and sustainability (Pohl & Tolhurst, 2010). If design is trusted for its power to address complex problems, and there is a need for strengthening shared value's practicality by providing operational guidelines to address the complex problems between the interests of society and business, a researcher may question if design could enhance shared value's practicality by elaborating on the merits of design for practicing shared value.

With such an inquiry, this paper aims to communicate the values of design when one seeks to address a wicked problem and to find a win-win solution, called a 'shared value', that aims to fulfill all interests of business and society. To explore the roles of design, key-value factors of design are investigated in two ways. As a first step, to identify the general perception of the value of design, the present paper reviews various judgment criteria and value factors of design in six international awards. Second, the study reviews scholarly works that define the various roles of design in business. Particularly, two conceptual frameworks in design are investigated in the context of shared value creation.

2 Five Value Components of Design

While design has received a spotlight as a competitive strategy for businesses (Martin, 2009; Muratovski, 2015; Yoo & Kim, 2015; Zec, 2010), the value of design often remains unexpressed for being tacit and unquantifiable (De Mozota, 2006; Heskett, 2017). When

design value is expressed only in quantitative terms, its value is often too simplistic (Dilnot, 1982), and it omits the original, sophisticated quality beyond the monetary dimension (Heskett, 2009). With this research gap, this paper first investigates the general perception of the qualitative value of design through a review of how design is judged in the general public and how its value is accepted in many other disciplines. We review various judgment criteria of design in six renowned international awards, which are often used as a common indication of the success of a design in commercial, governmental, and educational organizations.

Six design awards were selected for their global popularity, especially within public, corporate, and governmental recognition. Internationally, competitive design awards include the Red Dot Design Award (Germany), Design for Asia Awards (DFA Awards, Hong Kong), International Design Excellence Awards (IDEA, USA), International Forum Design Awards (iF Design Awards, Germany), the Index Award (Denmark), and the Good Design Award (Japan). They aim to recognize a design's value and to distinguish: a good design in the context of business (Red Dot, DFA, iF); the designated purpose of industrial society (IDEA); social, environmental, and economic sustainability (Index Award); and humanity (Good Design). Table 1 provides a complete list of the six awards' objectives and their judging criteria.

There were five keywords extracted as a common groundwork: form, business, innovation, society, and function. All six awards' judging criteria seek for excellence in the aesthetic and formal quality of the candidate. Second, all of them seek the commerciality, the economic impact, or the design's value for the business. As a third common criteria, five design awards emphasize an applicant's innovation and originality. Moreover, five awards' judging guidelines state that social and ethical responsibility is another important factor of excellent design. Finally, four awards elaborate a design's functional quality and usability as a key driver of a successful design.

Table 1 A list of international design awards: their objectives and judging criteria

Design awards (origins of the organization)	Objectives of the award	Judging criteria
1. Red Dot (Germany)	To distinguish excellent products, communication designs, and design concepts in the context of business	Degree of innovation, aesthetic quality, realization possibility, functionality, emotional content, impact, and differentiation
2. DFA Awards (Hong Kong)	To recognize good designs that create social and economic impact in Asia as role models for other businesses	Creativity, innovation, originality, usability, aesthetics, and sustainability
3. IDEA Awards (USA)	To recognize excellence in design as a 'benchmark' in the context of industry with 19 professional foci	Design innovation, user experience, benefits to the client, benefit to society, and appropriate aesthetics
4. iF Design (Germany)	To celebrate and recognize companies' design excellence and bestow a symbol of design excellence	Innovation and elaboration, functionality, aesthetics, responsibility, and positioning
5. Index Award (Denmark)	To acknowledge new tangible and intangible designs that improve life and offer sustainable solutions according to the UN's sustainability goals	Form, social and economic impact, and context

6. Good Design Awards (Japan)	To evaluate and honor good quality tangible and intangible designs to enrich humanity, society, and business	Humanity, honesty, innovation, aesthetics, and ethics

The review of the judging criteria shows that a design's value can be specified by five common factors: form, function, innovation, society, and business. It is not surprising that there are many value factors that constitute a 'good design.' Rather, it is an interesting outcome when we recall and compare it with the agenda for shared value creation. As shared value creation seeks to create a win-win value creation for society and business, a good design also seeks for a win-win value creation for society and business that is also innovative, functional, and aesthetically appropriate. The study results reveal that at the heart of design practice, design seeks for a shared value creation that synthesizes complex value considerations (Figure 1).

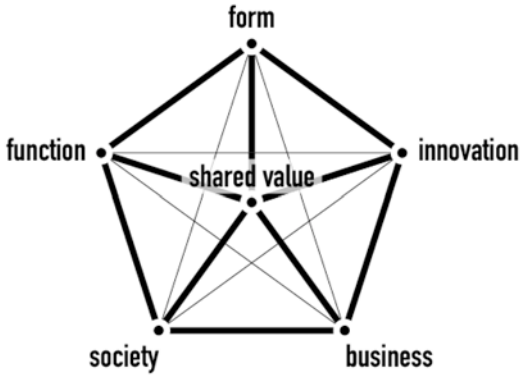

Figure 1. The five value components of design (the author's own illustration).

Design educators and scholars have already emphasized design's capability to connect one value to another. Dilnot (1982) defined the role of design as a 'synthesizer' of diverse practices, and Manzini (2004) expressed it as a 'mediator' between various interests. If we surmise Porter and Kramer's (2011) shared value, an intersection value of commercial value and social value can be connected and realized with consideration of the other three components of design. Following, form, function, and innovation, as three value components of design, will be reviewed in relation to shared value creation. Therefore, this paper will focus on how these three values theoretically strengthen the concept of shared value in design. Two particular concepts in shared value will be focused on from the standpoint of design. One is shared value's ability to create competitiveness "beyond trade-off" (Porter & Kramer, 2011, p. 64), and the other is its power to "unleash a wave of innovation" (p. 63).

3 Contemplating 'beyond Trade-Off' in the Lens of Design

A key criticism of shared value is that the concept might be too naïve (Crane et al., 2014) and unrealistic for its intent to create business value beyond trading off social or environmental cost. For example, because conventional belief is that most industrial development and economic growth are realized through the unethical use of labors and the destruction of the environment, shared value seeks for profit maximization without causing any social or environmental problems but with creating social or economic benefits with the

same means of economic growth. Then, it is a question of how to solve the wicked problem beyond prioritizing one value over another.

The review of the six awards' judging criteria does not indicate how jury members assess and decide upon a candidate design's form, function, innovativeness, value to society, and commercial qualities (Figure 1). We also do not know how to understand the relationships of each value or if there is a hierarchy, linkage, standard, or various levels within and between these five value factors. Regarding the relationships, one question can be surmised: do values have a hierarchy?

We can reflect on the ranking of values by recalling a famous design dogma, 'form follows function.' This statement was suggested by architect and design educator Louis Sullivan (Buitenhuis, 1957). Sullivan supposed that all natural and artificial things are evolved, and forms are developed due to changes in functional demands. Therefore, function changes prior to form, and function may be a primary concern before any formal consideration.

Despite the belief of functionalists, some scholars propose the contradistinctive annotations on form-follow-function statement. For instance, Sullivan and many modernist designers' dogma was rephrased by a student of Sullivan, Frank Lloyd Wright, who stated, "form follows function – that has been misunderstood. Form and function should be one, joined in a spiritual union" (Cheng & Blumenthal, 2008). Wright's statement has been re-emphasized for over the century. Victor Papanek (1972), a pioneer of social design, also mentioned that form has to be jointly considered with function where the system of function is a complex (Figure 2).

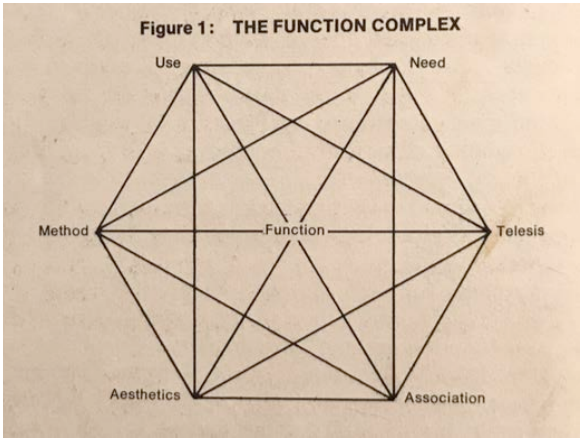

Figure 2. The Function Complex. Source: Papanek's [1973] Design for the Real World.

Anthony Crabbe (2013) further proved Sullivan's natural evolution theoretical perspective of form follows function to be wrong; he found there is no clear evidence to support that form is a subsidiary part of function. Moreover, Crabbe articulated that there was a critical reason why the functionalists disdained style. Functionalists, including Sullivan, perhaps considered style, image, and decoration as meaningless (Foster, 2003) and only a means of provoking conspicuous consumption of illusive images, as Baudrillard (1970) would explain in The Consumer Society: Myths and Structures. Even though he was aware of the criticisms on the misuse of form in design practice, Crabbe underlined that there is the necessity for the joint consideration of users' needs that includes all value, whether it is regarding form or function.

To summarize, Wright (Cheng & Blumenthal, 2008), Papanek (1973), and Crabbe's (2013) redefinition of 'form follows function' indicates two implications. First, design is about considering all value components as inherent parts of the whole system. It also implies that design is not about trading-off one value for the other or disregarding a subordinate value for a superimposing primary value. We can find a clue as to how to link design to shared value; design is about dealing with various values beyond trading off or ranking them. Shared value is able to be realized where formal, functional, and other value elements are collectively considered and aligned as a solution.

Secondly, the study of 'form follows function' suggests that style is not the only role of design. There have been concerned voices of design scholars that design education tends to restrict its role in style although it is evident that design is suitable for a larger scope, such as user-centered thinking or brand-driven innovation (Tonkinwise, 2011). Roberto Verganti (2009), a scholar known for design-driven innovation, even acknowledges both form and function as integrated components of innovation that fulfill users' needs. On the other hand, the Danish Design Ladder (Kretzschmar, 2003), or the four powers of design (De Mozota, 2006), implies that style is only one of many capabilities of design that assists businesses' competitiveness.

4 Contemplating Shared Value as a 'Wave of Innovation' in the Lens of Design

The previous section explored two value components of design (Figure 1), 'form' and 'function.' The analogy of the form-function relationship helps us to understand that all value components in the creation of shared value need to be considered jointly without any hierarchical relationship in order to create a value 'beyond trading off.' This section aims to explore another value component of design (Figure 1), 'innovation', in the context of shared value.

When Porter and Kramer coined 'shared value,' they persuaded readers that it has the ability to innovate and yield economic growth. In particular, they offered three ways of achieving innovation in the context of shared value:

1. Product, service and market innovation,
2. Process innovation with improved productivity, and
3. Local cluster innovation. (Porter & Kramer, 2011, p. 65)

Porter and Kramer (2011) presumed that innovation leads to economic growth. Their three methods of innovation can be deeply rooted in Schumpeter's (1934) economic perspective that innovation is the central vehicle toward economic growth in capitalism (Baumol, 1996; Hebert & Link, 2006; Heskett, 2009; Organization for Economic Co-operation and Development, 2005, p. 16). The historical background of Porter and Kramer's (2011) logic can be further explored through comparison with other scholars' innovation theories.

Table 2 provides a list of various categorizations of innovation theories as early as Schumpeter's (1934) two types of innovation, competence-enhancing discontinuity, and competence-destroying discontinuity. Schumpeter was an Austrian-American economist who favored 'entrepreneurial innovation' that aims for fundamental and interrelated change in industry, technology, organization, and society as long-term economic growth in business (Autio, Kenney, Mustar, Siegel, & Wright, 2014, p. 1106). Schumpeter explained that the degree of change in 'competence-enhancing discontinuity' is 'incremental' (OECD, 2005). It

improves style, function, technology, or the market (Tidd, Bessant, & Pavitt, 2001). The second type, 'competence-enhancing discontinuity,' was depicted as a level of changes is beyond improvement that is 'radical' (OECD, 2005) or 'disruptive' (McDonald, Raynor, & Christensen, 2015) enough to destroy the existing things and replace them with a new style, function, technology, or market system. Schumpeter insisted that 'competence-destroying discontinuity' innovation largely drives economic growth (Von Stamm, 2003). Most innovation theory stems from this 'creative destruction' mechanism of Schumpeter, and Schumpeter's theory on innovation elaborates on the levels of innovation, whether they are incremental or a drastic change.

Table 2 Various types of innovation

Author (year)	Labels of Categorization	Categorization Standards
Schumpeter (1934)	competence-enhancing discontinuity and competence-destroying discontinuity	Level (impact and degree) of innovation in the market
Heany (1983)	Style change, product line extension, product improvement, new product for an established market, start-up business (new market with known functions), major innovation (new product with new functions for markets and industries yet to be defined)	Methods and level of product innovation
Abernathy & Clark (1985)	Architectural innovation (re-configuration), market niche innovation (need finding), regular innovation (reflecting technological development), and revolutionary innovation (new radical market development with a new product and technology)	Methods of innovation
Tidd et al. (2001)	Product innovation, service innovation, process innovation, and business model innovation	Subjects of innovation
Tidd et al. (2001)	Incremental, radical, and transformation innovation	Levels of innovation
Oslo Manual (OECD, 2005)	Incremental innovation and radical innovation	Levels of innovation
Oslo Manual (OECD, 2005)	New product and quality change, process innovation, opening a new market, development of a new source of supply for raw material, and industrial organization change	Subjects of innovation
Verganti (2011)	Technology epiphanies, design-driven innovation (radical innovation), market-pull innovation, and technology-driven innovation	Functions (technology) and meanings of innovation
Porter & Kramer (2011)	Product, service, and market innovation; process innovation that improves productivity by redefining the value chain; and innovation that creates impact at the local cluster	Methods and levels of innovation in a shared value approach
Kumar & Puranam (2012)	Visible and invisible innovation	Visibility of innovation to the end users
McDonald, Raynor, & Christensen (2015)	Disruptive innovation and sustaining innovation	Competitiveness and market share due to the innovation
Heskett (Heskett et al., 2017)	Inching-up, product covering, product churning, and scaling-down	Methods of product innovation in an existing market
Heskett (Heskett	Technology-centered, marketing-centered,	Driver of innovation

et al., 2017)	image-centered, and user-centered	
Heskett (Heskett et al., 2017)	Little change or imitation, incremental detail and feature change, radical redefinition of a basic concept, and fundamental change from the introduction of new elements	Levels of innovation

More contemporary scholars have expanded the research on innovation. For example, there are more innovation theories that explain the methods (Abernathy & Clark, 1985), subjects (Tidd et al., 2001), or the driver (Heskett, Dilnot, Boztepe, & Poggenpohl, 2017) of innovation. Porter and Kramer (2011) have suggested that product, service, market, process, and cluster innovation are the various methods of reaching shared value creation and innovation. Similarly, Tidd et al. (2001) has offered a means of approaching innovation as product, service, process, and business model innovation.

John Heskett, an economist and design scholar, has reflected upon Schumpeter's perspective of innovation and has explored the roles of design as the 'how' element in driving innovation for economic growth (Heskett et al., 2017). In Heskett's (2009) opinion, design is comprised of qualitative factors that ignite innovation for businesses. Design is an operational tool to add and create (Heskett et al., 2017, p. 45) qualitative value (Heskett, 2009, pp. 78, 83) in the business activities. Heskett first articulated that incremental innovation is achieved by adding value through design (Heskett et al., 2017). Design can often add value to the existing elements by improving form and function. He specified four ways of reaching incremental innovation: 'inching-up' (expanding product variation from a low quality to a high quality sequence), product covering (expanding product variation by covering all possible functions in a particular industry), product churning (expanding product variation by developing various styles), and scaling down (expanding product variation from a high quality to a low quality sequence).

Furthermore, Heskett investigated that design not only adds but also creates qualitative value (Heskett et al., 2017). He implied that radical change in basic concepts or fundamental innovation is realized through design that enables strategic planning. Figure 3 depicts the roles of design management in the general context of business. At the bottom of the triangle, design practice adds value that creates an alteration of the product, service, and process. Meanwhile, in order to create a fundamental change, there is a need for a "long-term strategy" that "combines all elements of design in a company" (Heskett et al., 2017, p. 162). Therefore, Figure 3 illustrates strategy positions at the top that affect both design management and design practice. According to Heskett's theory, design can be employed as business management and as a strategy to implement innovation in the firm.

Heskett's four ways of adding value for incremental product innovation have many similarities to Heany's (1983) style change, product line extension, and product improvement. Moreover, Heany's other types of innovation, such as a new product for an established market, a start-up business (a new market with known functions), a major innovation (a new product with a new function for markets and industries yet to be defined), have many aspects in common with Heskett's terms, strategy design, and design as creating value for fundamental innovation.

Figure 3. Design as strategy. Source: Heskett, [2016] A John Heskett Reader

Like Heskett's framework that illustrates the fundamental need for strategy, other design scholars have emphasized the significance of strategic design for innovation. Manzini and Vezzoli (2002) emphasize that strategy design is capable of creating both tangible and intangible innovation in sustainable ways. Meanwhile, Morelli (2002) also articulated that a key advantage of system-level design is that it can fulfill the various needs of users. When shared value creation aims to remodel the capitalist system toward a sustainable version of capitalism (Porter & Kramer, 2011), it requires a systematic and strategic approach. A system-level approach can ignite fundamental innovation that leads to tangible changes, such as stylistic improvement, and intangible changes, such as 'business model innovation' (Tidd et al., 2001).

These elucidations coincide with the earlier exploration of the form follows function analogy. Strategy design or system-level design enables shared value creators to jointly consider all components (Figure 1) to meet the interests of society and business. In other words, when Porter and Kramer (2011) emphasized how shared value ultimately aims to make fundamental improvement in the capitalist system, the methods of shared value creation have to be seen as a strategic-level design that is beyond incremental product, service, and market innovation. When design is adopted as leadership and a strategy, shared value seems to have a promising future for solving wicked problems and creating a win-win solution for both society and business.

5 Conclusion

As a researcher who explored the role of design in the commercial world, Heskett stated that design provides operational tools to add and create qualitative values that generate profitable concepts and goods to enhance business competitiveness (Heskett & Dilnot, 2016). Furthermore, we discovered that shared value is ideal but a weak concept in practice because the task often deals with unrealistic or wicked problems that seek for innovation solutions beyond 'trading-off' commercial and societal value.

With this underlying background, the purpose of this paper was to theoretically investigate shared value's practical legitimacy in the perspective of design. We theoretically questioned what roles in design should be elaborated on to enhance the practicality of shared value. As a starting point, we reviewed the judging guidelines of six international design awards to identify elements that comprise quality in design, of which there are five value components:

form, function, innovation, society, and business. Through the review of literature concerning the relationship between these values and theories on innovation that creates value, our study leads to the conclusion that all five components have been considered jointly as a system and a strategy.

This paper aims to theoretically explore the implications of design in relation to shared value as a preliminary desk study for further doctoral research. The study was conducted using only theoretical analysis of academic works and secondary data. Two conceptual frameworks (Figure 1 and Figure 3) were illustrated as significant and relevant starting points to expand further research in real industry settings. Porter and Kramer's (2011) shared value has not been extensively explored in the field of design (Kim, 2018), yet the present article has reviewed theoretical clues as to how to connect shared value from the standpoint of design. Further research questions have been formulated, including: what are the key challenges and practical tools of design practitioners who have the experience to create shared value (as fundamental innovation) at a strategic level? Learning from the finding in this paper, further research shall examine process of shared value that contains practical challenges and solutions how practitioners reach at real business strategies that align social and business purposes.

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All Innovation Is Social

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We examine and critique today's emerging design theories of a social and community focus (e.g. Social Innovation and Social Design), which we contextualise in practice, drawing from collaborations with two community organisations whose objective is to create technological and sociological change in and with their communities. Drawing from interview data and reflective logs we discuss the connections and disconnections between the design literature and our findings, detailing tensions between technology and community and between the agency and expertise of social innovators, and that of the community they intend to benefit. Whilst recent design theories provide some confluence with practice, they point towards, rather than coherently define the phenomena of how innovation forms from communities, as they overlook the material constraints that undermine production of shared value. We discuss how the outcome of innovation and design is synthesised by the thesis of agency and approach of our organisations, and the anti-thesis of material and economic conditions present in the community. We conclude by describing a form of servant-servile leadership that is required in designing innovation with community, producing shared lines of reasoning around the design of innovation and shared ownership over outcomes.

Keywords: social innovation, social design, design activism, collaboration.

1. Introduction

In this paper, we contribute emergent findings from a research collaboration with two organisations; The Baking Army and Electric Hand, and, an interview with the director of a social enterprise support organisation, Social Enterprise Insight. Drawing from our analysis, we go on to introduce relevant historical and contemporary design literature, to examine synergies with and contextualise findings from our collaborative practice. We finalise by proposing two design opportunities: first, how social innovation and social design can be better understood as a dialectical synthesis of opposing tensions and secondly, that leadership over innovation must be continually challenged to succeed in delivering lasting impact, necessitating the creation of a rebellious community that holds experts to account.

1.1 Establishing Community Collaborations

The first author met with potential research partners by attending a university community business event in the North East of England (hereafter 'North East') and through existing contacts on a Scottish island (hereafter 'The Island'). We recruited two organisations in late 2017 and have been collaborating with them since then on a university research project into social design in the digital economy. The organisations are The Baking Army, a community

bakery whose objective is to create a sustainable food infrastructure in the North East, and Electric Hand, which aims to mobilise the high-tech economy on a Scottish island by fostering collaborations between the technology sector and organisations on The Island. In addition, we draw from an interview with the director of Social Enterprise Insight, which supports innovative social projects across the North East, the director of which has more than 15 years' experience developing Social Innovation, Community Led Development and Social Enterprise in the region.

(Left) The Baking Army runs market stalls to generate profits that are directed into social projects, such as baking workshops to promote healthier eating, sustainable food production, and skills development for those who are differently abled. (Right) A flyer designed by the first author to promote Electric Hand's workshop with local farmers in collaboration with a Scottish university to promote prototypical IoT technologies in rural farming.

1.2 Motivation for the Research

Our particular interest in these organisations was threefold; they are small scale SMEs, with fewer than 10 staff, yet motivated to initiate a societal change; they are operating in resource constrained environments without the necessary capital investment to support the changes they seek to create; and finally, their goal to work with their (proximate) communities are facilitated through both physical and digital spaces. Furthermore, it was deemed relevant that both The Baking Army and Electric Hand are seeking to create technologically-enabled change; albeit in different ways with different emphases and motivations. Furthermore, their different settings—The Baking Army being mostly urban, and Electric Hand being rural—was considered useful for probing the relevance of environmental setting on this work. In this paper we work with a broad definition of technology that includes techniques such as language (Coeckelbergh & Funk, 2018) that are constituted by social relations and the political economy (Booth, 2013; Smith, 2019).

We agreed an exchange of design services with both organisations as part of our collaboration. This involved 'shadowing' the organisations' leads as their plans took shape and developed and also contributing to enabling the changes they each sought through our communication design and research skills. The first author recorded this ongoing process through reflective visual logs and diaries. This knowledge exchange approach aimed to create a relatively equitable basis for mutual benefit and impact.

2. The Research

The first author conducted semi-structured interviews with the three leads, to gather insights on their roles, positioning within their organisations and their wider community. The interviews were conducted between December 2017 and May 2018 and totalled 5 hours. We

asked open questions to encourage reflection on the relationship between the organisation and the community e.g. 'Why are you interested in working with this community?'. We also asked them to each comment on opportunities and barriers they had encountered in engaging and innovating with their respective communities. We also asked them how they conceptualized their role (did they see themselves as an activist? How political was their work?); and ways in which this work was validated, or not, by their community. In addition, The Baking Army and Electric Hand interviews involved their leads participating in various visual mapping tasks to map their networks of suppliers and collaborators.

We audio recorded and transcribed the interviews. We then qualitatively coded the transcripts using a grounded theory approach (Charmaz, 2006). This resulted in 45 open codes which we constructed into three themes: Visions of Change; Challenges of Developing Social Value in a Failed Market; and Listening and Acting, which we discuss below. The rest of the paper is organised thus: we go on to discuss the reflective visual logs and diaries, before contributing a tabled summary of key design literatures. This triangulation (see Figure 1 below) comprises our underpinning methodology and informs our subsequent discussion on the intersection of theory and practice, expertise and collaboration and technology and community.

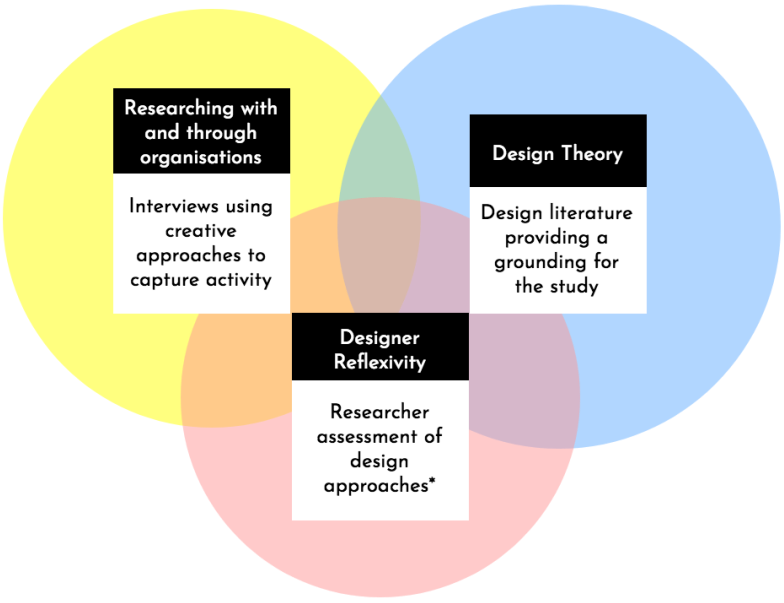

*Figure 1. *Creative work such as designing promotional materials and visual mapping (see Figure 2) accompanied by visual logs and diaries.*

2.1 Visions of Change

This theme evidenced that each organisation's foundational activity was motivated by a particular sociological vision, and that this related to deficiencies in state funding and existing technological infrastructure. In the case of The Baking Army, these deficiencies primarily related to the inadequacy of urban food infrastructure, where underdeveloped distribution and mass-production meant that there was poor access to affordable, nutritious food.
The founding member of the organisation described himself in interview as previously a '*global activist'*, who had been involved in lobbying government. However, they '*don't have a lot of belief in that approach'* he said, referring to traditional forms of influencing representative democracy such as lobbying, before going on to say how he felt it was

necessary to '*be a producer'* working at a grass roots level. In order to develop a more equitable food system he had decided: *'bread was a good way to start with this complex challenge'* and was consequently raising money towards establishing a 'community food hub and social bakery'.

Both The Baking Army and Electric Hand aimed to address technological inequities. The Electric Hand lead described the communications infrastructure on The Island as suffering from a '*broadband deficit'*. The Baking Army described food production in the North East as '*unequitable'* and '*unsustainable'*. All three organisations' leads referred to having to be vocally activist, acting on behalf of their respective community: *'someone's got to do it'* said The Baking Army's lead. The director of Social Enterprise Insight's reflected: *'There generally has to be a driver [of innovation] ... often without any formal skills at all, and often doing it quite badly in some ways, but with a real passion to make it happen…'.* All three interviewees demonstrated how they have each taken centralised power to develop their particular community innovation.

Both The Baking Army and Electric Hand leads assumed leadership and used their expertise. The Baking Army referred to mobilising others in order to '*show [the community] by doing, make something tangible, and develop momentum that way'* . Both organisations' strategic goals are to create something scalable by first demonstrating at a smaller scale, and mobilising the community to realise and scale change. The organisations themselves form '*an exemplar … demonstrating a model that can be scaled and replicated'* (Baking Army lead). Interestingly, all three respondents discussed their community as separate to themselves and made clear distinctions between their organisation and the community, which '*needs to be open and willing to invest [economically through time and resource]*' (Electric Hand), and to engage in the organisations who in turn aimed '*to nurture them.. their ideas*' (The Baking Army lead). This separation from their community may be a consequence of taking on private ownership structures as required for legislation and in order to receive funding; The Baking Army was in the process of registering as a Social Enterprise limited by guarantee from its previous status as a community group; Electric Hand operates as a Corporate Social Responsibility Scheme or 'CSR' to a private consultancy. As such, these organisations are constantly in tension between social (activist) action and the regulatory, legal and economic infrastructures in which they operate, creating what Social Enterprise Insight's director referred to as *'paternalistic'* structures and processes that can become so entrenched that the organisation effectively occupies a space of activism that might otherwise emerge from the community, which '*disavows itself*' from engagement.

2.2 Challenges of developing innovation in a failed market.

This theme articulates the interviewees' expressed challenges of delivering social value in an economy focused on private gain. *'Running a business is hard, running a business in a social space is even harder… you are usually working in places of market failure*' (Social Enterprise Insight). The interviews surfaced many contradictions and tensions across resourcing, financing desired change, operational costs, and authority. All of these material constraints can undermine the social purpose of the organisations, forcing them to prioritise operations that support viability rather than develop social impact. Collaboration with and in the community is necessary to address the lack of financial capital. Thus value generation and exchange requires community buy-in and contribution (e.g. through volunteering).

However, problems can arise because of competition between organisations for limited funding and the highly constrained resources in their communities.

Both The Baking Army and Electric Hand had their inception in activist campaigns, only later transforming into social enterprises to sustain themselves and scale up, through primarily accessing grant funding. When profits were made, for The Baking Army through bread sales and for Electric Hand through digital infrastructure consultancy, these were required for maintaining day-to-day operations, inhibiting capital development for scaling social impact. Whilst investment capital can be raised, this is only by short term grant funding or private loans. These constraints affected the organisations' ability to employ and provide job security to new staff. There was a sense of stop-start and scattergun or somewhat disorganised operational activity, by the duality of their oft-competing aims. As The Baking Army lead put it succinctly: '*…[the] route to viability is often not very clear'*.

Day-to-day operations limited the time available for The Baking Army's staff to explore '*more strategic ideas*' in order to enable innovation: *'we don't get enough time to do that without overstretching myself personally – it's just not possible'* (lead). This epitomises a continual balancing act of social value delivery and private value retention. Time is lost to delivering the essentials e.g. networking, developing strategy and communicating with the wider community. These multiple constraints often, as described by Social Enterprise Insight's director *'force difficult decisions'* between socially impactful activities and economic viability.

Both The Baking Army and Electric Hand's leads pointed out how the eco-system of support surrounding their organisations is hindered by wider ongoing under-investment in the pubic sector and funding regimes. This has left a legacy of mistrust amongst potential service users, with service providers seen as '*self-serving*' (Social Enterprise Insight's director). Furthermore, the organisations deemed third party funding (from regional/national government or private sector enterprise grants) problematic, with other providers *'not (socio-politically) engaged'* and unstrategic (The Baking Army). Enforced competition for scarce funding disincentivised collaboration, resource, and even ideas sharing:

'…the bigger idea … will come through collaboration … organisations aren't used to doing that, the community organisations very much so, they are competitors – in a different way to ourselves and another bakery, they are competing for funding and interest from whatever stakeholders they need to be involved … once you share your ideas, someone else might be in a better position to get the funding to take that forward'. (The Baking Army) The Baking Army's lead went on to recount how their idea to form a community food hub was shared with another social food project, which took and promoted the idea as their own in a funding bid.

Whilst those interviewed see community engagement and social mission as symbiotic, the question remains as to how to reconfigure innovation to both draw from and also deliver social value. One approach was to utilise novel business models in order to align running a private business with delivering social value, such as by structuring their value proposition (the key motivations behind users' take-up and use of a service, see Strategyzer, 2019). Rather than trying to sell a service to potential beneficiaries directly, organisations identify a value proposition that benefits organisations with the capital to enable service delivery. For example; Social Enterprise Insight's director explained how a start-up enterprise focused on tackling obesity in a resource-limited community could be funded through commission by the

National Health Service, which would hope to benefit from a reduction in patients with weight related conditions.

However, limited access to the right skills was a core limitation. *'The challenge I see is the skills, and the human infrastructures sitting alongside the digital infrastructure, the copper and the wireless, without which nothing else can happen*' (Electric Hand). Focusing on producing novel technology in this resource limited space requires participation and the freely given labour time of the community, otherwise it is inert, without any channels by which it can bring about positive change.

In summary, these organisations gain economic value from their community collaboration that enables them to overcome the inherent challenges of resourcing innovation without private investment.

2.3 Listening and Acting.

This relates to each organisation's future direction being informed by listening to and dialogue with the community. A process described by The Baking Army as generative, even catalytic: *'giving people … encouragement to develop their own ideas and implement something real*'. Structuring this collaboration creates demands on resources, but can allow organisations to scale through community contribution, rather than private investment.

Electric Hand's lead saw strategic development as a collaborative process:

'*... because [the community] are bringing things in, experience, understanding, knowledge of the area ... that enriches the content that everybody else is going to feed on, it's like a giant bowl, and you're sipping at the edges, and people are putting more ingredients in, and the soup is getting more interesting as it goes…'* (Electric Hand).

Maintaining this level of collaboration requires changes in leadership models, as described by Social Enterprise Insight's director, that *'actually enable the organisation to thrive... that ... have somebody who's driving the change but then they've created a culture where people feel they can contribute in the right sort of way and those seem to be the best'.* However, she continued: *'I think where you're trying to reach consensual decision making, they kind of flounder quite a lot.*' Here, collaboration is not 'ultra-democracy' (where all participants are consulted on all decisions) as this stalls the process; instead, as Social Enterprise Insight's director advised: *'stopping talking and get things done'.*

Social Enterprise Insight's director summarised this as '*servant leadership'* that involves partners *'assembling ideas in the right way*' and then *'testing them with the community*'. This involved listening closely, organising and synthesising relevant ideas into coherent designs that can then be taken back to the community, creating the right infrastructure for the community to, as she said, '*contribute in the right sort of way'*.

2.4 Accounts of the Action.

So far we have shown how organisations were responding to a sociological vision of change in opposition to economic and infrastructural deficits. In wanting to produce scaleable social value, the leads were challenged by scarce capital, organisational constraints, and by the same economic and infrastructural deficits that they sought to address in the first place. In order to overcome these economic challenges, The Baking Army and Electric Hand had structured collaboration with/in their respective communities, who could enable service

delivery by contributing labour time and other resources, by providing strategic direction.

The first author's background enabled us to offer design services to both organisations, meanwhile testing specific design research approaches. Additionally, this enabled their 'embeddedness'; to observe and capture more intangible factors in each organisation's activities. Furthermore, our presence as a volunteer designer encouraged other community members to become involved in the projects. One volunteer took on a marketing and communications role for The Baking Army for personal experience. This is an example of resource capacity increasing cumulatively as projects scale; people's involvement attracts others' interest and contributions. It also demonstrates how a researcher's involvement can raise awareness and help signal trust or confidence in the community organisation. However, this responsibility does place additional pressure on the researcher in ensuring that the organisation is working democratically and listening to its community (Kimbell & Julier, 2019).

To evidence the tangled web of stakeholders, organisations are working amongst, our design interventions included mapping activities to solicit and document each organisation's networks (see Figure 2). These acted as a pertinent form of 'antefact', an accessory to the act of design that became its own outcome (see Cockton, 2017) and were useful in developing and planning new fundraising campaigns for the later stage of the research. Later in Summer 2018 the first author used ideas from Gamification (Seaborn & Fels, 2015) to design a community engagement survey used by Electric Hand (see Figure 3). Afterwards, Electric Hand's lead commented how this proved both *'an interesting and powerful way of capturing information, preferences and feelings about connectivity that's open to different demographics*'.

The Baking Army took leadership from the community in it's engagements with the community where they aim to create a new food hub. They ran surveys at events created by existing organisations, with guidance from local community members. In Summer 2018, Electric Hand participated in a connectivity forum on the island to gain preliminary insights into issues amongst local groups (such as schools, businesses, emergency services and the local health trust), around which Electric Hand subsequently sought to create new events. In this way, they 'piggy backed' on existing initiatives, tailoring their very limited resources accordingly. This has led to the organisation pivoting its original objective of island connectivity towards digital skills development, informed by its own public engagement, using the gamified survey developed by the first author (see Figure 3). In this, Island participants attempted to 'wire up' the islands industries, towns, and services with connectivity and prompted discussion on the digital deficit within The Island.

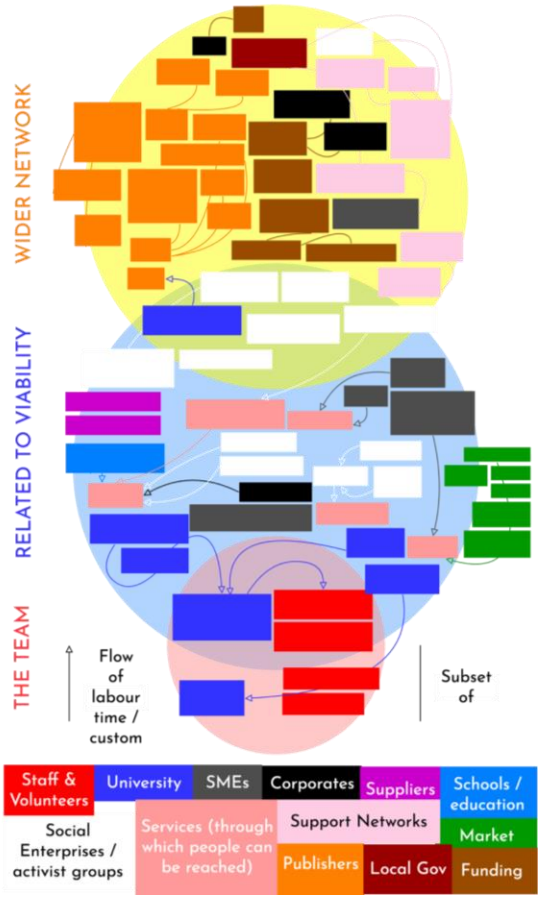

Figure 2. A co-created network map for The Baking Army (organisation names redacted). Our research found aspects of the sharing economy present (Light & Miskelly, 2014; Gauntlett, 2011), with numerous other social enterprises supporting The Baking Army and extending its impact. These myriad, ad-hoc collaborations help the organisation develop new partnerships to deliver training courses and other services.

Figure 3. A simple engagement game used by Electric Hand during an island festival.

3. Design theory since the crash.

An imperative in this project was to use design practice to probe the relevance and distinctiveness of design literature. As part of an ongoing analysis, we contribute here an overview of contemporary philosophical design disciplines and methodologies.

	Definitions from literature *(from indicative literature unless stated otherwise)*	**Summary**	**Indicative literature**
Social Design	The collective task of developing an artefact or putting in place processes for the public good.	Often used as a 'catch all' term for designing that has a social (rather than commercial) orientation. Encompassing some of the fields below in this table (Armstrong, Bailey, Julier, & Kimbell, 2014), Social Design addresses multiple situations, largely design for political exchanges with the public sector, but also some community based work. Focusing on outcomes that produce 'social value', social design is open enough to encompass designing that both supports and challenges the status quo.	Chen, Lu-Lin, Hummels, & Koskinen, 2016; Dourish, 2010
Social Innovation	Driven by 'bottom up' collaboration to develop new ideas from existing elements.	As Social Design above, Social Innovation has a broad enough meaning to encompass a wide variety of design activities. It is differentiable from Social Design in its theoretical focus on socially enabled process rather than socially valuable outcomes, though both advocate similar design processes.	Manzini, 2014; Mazé, 2014; Mulgan, Tucker, Ali, & Sanders, 2007
Responsible Innovation	An emerging concept in the EU context that highlights the relevance of social-ethical issues in research and innovation practices (OZSW, 2019).	Perhaps the inheritor of Victor Papanek's Responsible Design (1971), this seeks to develop innovation processes that are environmentally sustainable, convivial, and humane. Responsible Innovation typically involves participatory and co-design processes.	Blok & Lemmens, 2015
Utopian, Molecular and Sociological Social Design	Socially oriented or otherwise ethical design practiced towards a sociological agenda.	Koskinen and Hush (2016) further characterise Social Design into three distinctive phenomena ● design towards *utopian* futures—Buckminster Fuller's Design Science as an example (Fuller, 1971) ● *Molecular* Social Design towards incremental change— such as contemporary forms of ethical design practices ● *Sociological* Social Design— in which a larger sociological conception of change is held.	Koskinen & Hush, 2016

Design and Publics.	Designing publics refers both to the way publics arise out of design interventions and to the generative action publics take—how they 'do design' as they mobilize and act in the world.' (MIT Press, 2019).	'Publics' as used here refers to Dewey's analysis of political movements of being affinities of self-interest (1927). As it is highly individualising—in this theory it makes no sense that a white male would support movements against racism or patriarchy—this conceptual device is cited as giving us a means of designing interactions that can leverage self-interest into collective action and supporting social change. There is some variation of terminology; *Designing for Publics* and *Designing Publics* refers to taking the designing to a public or mobilising (new) publics. *Designing with Publics* is collaborative design towards mapping existing publics.	Le Dantec, 2016; Light & Briggs, 2017
Contestational Design; Agonistic Pluralism	Aims to promote particular agendas in contested political arenas (Hirsch, 2008).	Designing ambiguous or controversial spaces and interactions in the community where opinion can be crystallised or deconstructed. Borrows from a Marxist, rather than Deweyian conception of social formation, in which the individual is subsumed and produced by social relations, rather than individually relating to them. This places the focus of designing towards effecting discourse rather than affecting the individual.	Julier et al., 2016; Korn & Voida, 2015; Mouffe, 2009
Citizen/ Citizenship Design/ Design as Citizenship	Designing as 'activist citizen' or through collaboration with citizens to generate responses to emerging problems, political issues and social phenomena.	More disparate than other philosophies and approaches listed here, but has a distinctive positioning of the designer as both constituted by and constituting their socio-political relations. Designer as an actor in the political relations that (re)produce them.	Grout, 2018; Heller & Vienne, 2003; Lewis, 2017
Design Activism	Design playing a central role in promoting social change, raising awareness about values and beliefs, and questioning the constraints of mass production and consumerism.	The literature is associated mostly with the production of artefacts for propaganda purposes. However, broader manifestations through objects and services concerning the design of and towards activism also specifies the use of design for radical political purposes.	DiSalvo, 2016; Markussen, 2011
Digital Civics	Uses digital technologies to empower citizens.	Broadly encompasses designing technology for the relationships between people and the state, and each other in civic responsibility. Typically mobilised through a civic university research agenda. Draws on participatory and co-design methods.	Olivier & Wright, 2015; Vlachokyriakos et al., 2017

Civic Tech	Questions how we shape technology and how technology shapes us; how we govern, organise, serve, and identify matters of concern for communities.	Coming out of the Human Computer Interaction community to describe the interplay between 'civic' and 'technology', mostly differentiable from Digital Civics in its application through private sector crowdsourcing and crowdfunding platforms and apps rather than service design in the public sector.	Boehner & DiSalvo, 2016; Knight Foundation, 2013
Transformation Design	Explores design's potential to shape the future of organisations and society.	Developed out of organisational design, service design and change management. The methodological approach starts with ethnography and user-centred approaches. Differentiable in its synthesis of wider organisational identity through observation and collaboration with individuals working within its lower levels.	Stephan, 2017; Yee & White, 2016
Participatory Design	The direct involvement of end-users and other stakeholders in designing or implementing system designs.	Preceded and overlaps many other approaches (mentioned here as it remains a distinctive sub-discipline). This philosophy originated in the worker's movement, in processes of designing factory equipment with the workers who used them.	Carroll & Rosson, 2007; Ehn, 2016; Kusano, Ohno, & Kohtake, 2014
Design Thinking	Human-centred approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success.	Proposed methodology comprising numerous tools borrowed from user-centred and Participatory Design as well as ethnographic approaches. Largely applied in the private sector as a research tool to support service design (e.g. RBS's 'Open Experience' team (RBS, 2019). It has also been applied in third and public sector work, with proponents citing its capacity for social change.	Brown, 2009; Brown & Martin, 2016; von Busch & Palmås, 2016; Yee & White, 2016

3.1 Theory in the context of practice.

There is a degree of confluence with aspects of these design theories as set out in the table above, which loosely frame what is happening in the research collaboration. However, they lack clear guidance to inform practice. Social Innovation's theory of emergent innovation, where 'experts' channel innovation from and through the commons (Manzini, 2015), partly describes the approach of listening and acting we encountered (see section 2.3). Or; the ways in which our organisations have used existing networks and local voluntary labour to provide insight and strategy, direction in the design of services, and at times channel and provide resources for the organisation's activities (see section 2.4). Our organisation leads are attempting to innovate with the community as Manzini's 'experts', attempting to structure community contribution, as discussed, maintaining this level of collaboration requires changes in leadership models, as described by Social Enterprise Insight's director, taking and representing ideas '*in the right way'*, to co-develop innovations. However, no working model is provided for this in the literature, aside from demonstrations of workshop and co-design methods. The theory does not address issues of resourcing, legal structures and the need for economic viability, which together distance the organisation from the community and force it to centralise value in order to survive (see section 2.2). In an imaginary world without the social relations of ownership made necessary in capitalism, experts might be able to channel innovation in their communities more freely. Manzini recognises that this conceptualisation points towards, rather than defines the phenomenon of how 'Social Innovation' emerges (Manzini, 2015). But the theoretical separation of 'expert' and the 'diffuse design' (the designing and creative potential of everyone in the community, see Manzini, 2014) is undermined by the reality that in practice, both experts and members of the community are not in fixed positions but frequently interchange.

Design approaches such as iterative prototyping and participatory co-design occur frequently in the literature. Whilst they have been criticised for promoting the agency of the expert (designer/researcher/our organisations leads) over participants in forming objectives and contextualising outcomes (Blok & Lemmens, 2015; Johnson et al., 2017; Kimbell & Julier, 2019), the literature often endorses these methods, somewhat uncritically. In our practice, organisation leads invite substantive contributions from their user communities, but struggle to resource meaningfully ongoing consultation, as the demands of core activities (producing and selling bread in the case of The Baking Army) mean that they do not '*get enough time to do that'* (The Baking Army lead). The design literature eschews difficult conversations about funding processes of co-design and who benefits (economically or otherwise). The servant leadership role described in section 2.3, extends further than instances of 'bolt-on tool kits' for consultation (IDEO, 2015). This instead intends that the community meaningfully informs objectives and contextualises outcomes of design processes. These activities challenge the validity of the designer as having agency over authoring both the inception and outcomes of design and innovation processes, both of which are generally espoused by Social Innovation and Social Design literature.

We argue that we need to design relationships where leadership is challenged to ensure activities serve the real needs of communities. Korn and Voida (2015) show how fostering contestation through designing controversial and ambiguous spaces can help promote engaged and lively debate. However, in the practice of designing innovations with their respective community, our organisations need contestation to singularly focus contribution

towards innovation and design, rather than fragment efforts of the already resource-constrained community, in which social projects are forced to compete with each other (see section 2.2).

In attempts to be apolitical, much of the literature has ignored that designing in this space is inherently political. A designer often has political power and privilege in the design process; this is true in our organisations. Their activity is predetermined by a sociological vision of societal change (see section 2.1) as described by Koskinen and Hush (2016). By eschewing the political ideology of both participants and its authors, the literature could be used to inform Social Innovation towards fascism, where the rich class 'emerges' the ideas in its own commons to oppress all other classes, in line with fascism's ideological goal of solidifying unequal economic distributions of wealth and opportunity. As things stand, Social Design could be used as a methodology in designing civic relations with an oppressive state e.g. making forms for reporting citizens to the secret police more accessible and user friendly.

3.2 Designing for 'the commons' wasn't *news from nowhere.*

In the advent of the great recession in 2008, we have seen a multiplicity of design philosophies and methodologies emerge. Those included in the table in section 3 share an intent to create technological innovation that produces 'common' value with communities. Though unsystematic, the opposition to design as a vehicle for accumulating private capital is clear; this is what binds this literature together.

Technology—in the broad sense as used in this paper—and community was the defining intersection in our analyses of interviews and practical design. We define community as that which is held in common by the community—whether this involves a geographically or culturally proximate group of individuals, a global community of technological product users, or indeed, design researchers. This means that the organisations and the communities they seek to serve are party to the same commons. Analysis of the interviews showed that organisations also aim to prioritise the production of common value—in alignment with the literature—however, scarce capital, and the legal requirements imposed by funding bodies, become dichotomous with these aspirations. Instead they are encouraged to effectively privatise the value provided by their community. Pragmatically, this is advantageous for capitalism in the current economic crisis, where we need to negate the risks associated with private capital investment into research and development. Clearly, national austerity policies have necessitated alternative ways of configuring innovation and delivering services; as seen in this study. However, all this raises critical questions around resourcing, and how, and *for whom* these endeavours are designed and delivered.

This discussion on how to design technology that produces common benefit predates the term 'design' as we know it today. The socialist pattern maker William Morris argued for the protection of the egalitarian arts and crafts against industrialisation (Morris, 1890; Pevsner, 2005). In the 1920s, the October Group (of the communist revolution in Russia) and the Bauhaus all argued that industry should be repurposed away from capitalist production and towards 'communal luxury' for the people— establishing values that became today's 'industrial design' (Gordon & McCormick, 2015). At the end of 'the great society' and the beginning of the counterrevolution against the period of social democracy following WW2, design theorists attacked what Buckminster Fuller called the 'designedly ignorant' consumer industry. Papanek (1985) promoted moral responsibility in designing whilst John Chris Jones

(1991) was part of a generation that created 'design methods', with the motivation of using design to liberate, rather than 'fix in place' the users of technology. Here Jones considered users subject to, rather than participants in the design of technology.

This glimpse into design history demonstrates how innovation around technology is often mirrored by the struggle to reclaim the value it produces. As technologies' capacities are developed, new ownership enclosures are devised to accumulate the value it produces. Similarly, capitalism was developed through privatisation of common land; whether the enclosures in England or the clearances of Scotland; and so too have new technologies such as social media been privatised in recent decades (see Kleiner & Wyrick, 2007).

Both The Baking Army and Electric Hand are responding to a social deficit; one concerning food inequalities, sustainability and distribution, and the other remote digital (dis)connectivity. If digital technologies provide opportunity to raise standards of living but only reproduce and reinforce inequality and poor social conditions, then their reclamation into common value (through e.g. Social Innovation) is predetermined.

3.3 Navigating tensions in leadership: Design emerging in the dialectic.

The literature is returning to older ideas e.g. Dewey (Dewey, 1927; Light & Briggs, 2017); and Marx (Korn & Voida, 2015; Mouffe, 2009). Perhaps popular post-modernist conceptions of community from the latter part of the 20th century are now insufficient. As designers and researchers, we inherently constitute a power relationship (Foucault 1978), and by declaring their validity 'to lead', our organisations do also. This is an unavoidable contradiction; to author change both Electric Hand and The Baking Army have had to constitute authority, to maintain their organisations as legal entities, fundraise, and to also be accountable for delivering promised outcomes. Additionally, the requisite skills to enable design and innovation are not evenly distributed. Our organisation leads have expertise that is centralized, particular and finite, but which also must be distributed, developed and built upon. This 'hierarchy' (Heimans & Timms, 2018), is not a problem until power becomes ossified, and the power to effect change becomes alienated from the community. Decentralisation, similarly, is not problematic until it fragments power, leading to a '*floundering*' as recognised and described by Social Enterprise Insight's director. In any case, it may be impossible to fully distribute agency over innovation., As Freeman (1970) argues, in attempts to produce flat hierarchies the most charismatic and well connected end up constituting a class of their own. We argue that this apparent binary between designer and user, expert and 'everyday' as present in the literature, undermines a more nuanced understanding. Our research suggests that centralisation and decentralisation are not mutually exclusive, both are necessary in developing any viable system of innovation.

Our study uncovered a style of *'servant leadership'* that has the potential to navigate tensions between organisation and community. Leadership can be centralised, but can only succeed as long as it processes the unsystematic, decentralised nature of a community, and is invested in producing shared ownership structures that leverage contributions of value to overcome the economic challenges facing both our organisations. Participation is thus motivated by self-interest of all those involved in the production of shared value.

4. Conclusion.

4.1 Theoretical implications

The theory behind the Social Innovation and Social Design is not distinctive or readily defined, we show here that it is part of an historic struggle to repurpose technology towards building common value, rather than accumulating private capital. Both ‘design’ and ‘innovation’ are often synonymous in their meanings, in that they both exploit new ideas. Their distinctiveness becomes immaterial in light of political considerations of *for whom* we are designing innovations. The disconnect between the different cases and methods in the literature, and the wider political visions that drive them in practice, make applying design ‘theory’ to any practical work supporting large scale social movements or causes more challenging. As political intentions are not explicit, we must continually rehabilitate and justify our political intent whenever these approaches are deployed.

We propose a theorisation of ‘community’ as a dialectical opposition between individuals within it and the commons they share. Design here is more than just a ‘socially mitigated discipline’ (Potter, 1989). Through Material Dialectics, which involves understanding phenomenon by the opposing tensions that produce them, we can see that the outcome of innovation and design for our organisations is synthesised by the thesis of agency and approach of our organisations, and the anti-thesis of material and economic conditions present in the community. The community must possess the surplus time and requisite infrastructure (factors such as digital literacy) to contribute to overcoming inherent constraints in designing for the production of common value.

Similar tensions such as those between service-users and organisations, and the technological ‘push and pull’ theorised in markets, exist in commercial innovation also. Beyond the highly collaborative nature of design, our expectations of design are informed by the social web of designed artefacts we interact with, hence we can say that all innovation is social. A rebuttal for those who say that competition for profit drives innovation is that all innovation was originally enabled by the highly unprofitable reproductive labour of mothers (Davis, 1981; Duffy, 2007). Social relationships driving design and innovation are constituted by the material conditions surrounding them; i.e. available capital and surplus labour time available in the community, levels of education and digital literacy, the quality of local infrastructure etc. Social relations predetermine design work in this space; who owns the outcomes, who possesses the relevant expertise, what ownership (class) and power dynamics are at play.

The emancipatory potential of digital technologies to improve living standards is in a dialectical tension with relationships involving ownership and unequal distribution of profits. Such tensions ultimately dictate the character of Social Innovation, Social Design, and the efforts to involve the community in the case of our organisations, who must separate themselves from the community they seek to serve, but for whom, sharing and collaboration (including volunteering) are a practical necessity to overcoming limited resourcing.

These tensions between material conditions and social relations surrounding innovation absorb Social Innovation’s notions of ‘expert’ and ‘everyday’ (Manzini, 2015) That is, that the expert’s role in Social Innovation is to solicit the potentiality of ideas in the everyday ‘commons’. Further, this lens—borrowed from revolutionary theory—shows how the ultimate

character of Social Innovation appears in the opposition between the agency of an ‘expert’ (as innovator/activist) and that of the community they seek to serve.

4.1 Design implications

Theory advocates that the organisation sits at the centre, and the community at the boundary. But in practice, they are in an opposing tension with each other, that synthesises the relationship and its outcome, contestation between the two is necessary for there to be a meaningful collaboration at all.

We need leadership in social research and the space of designing communal innovations that gets its strategy and tactics from the community; and shares ownership with them in order for the community to not disavow itself through apathy or the presumption of paternalistic agency. It is right therefore that they (the collective or individuals) challenge the social innovators even to the extent of bombarding them with demands, or entering and occupying organisations to ensure the community’s needs are represented, just as stakeholders challenge commercial processes of design where there is a vested interest in the success of the outcome. Without entrenched authority, the communities' agency over outcomes must be systematically channelled through a servile form of leadership, that ultimately depends on the community to realise the innovation.

From outside of design literature, design for leadership towards a democratic innovation design is articulated coherently in the Chinese tradition of mass work. This is a method of developing strategy in community organising where a mass-line (of reasoning) is continually sought between organisers and the community in which they are trying to provide leadership (Moulfwad, 2016). This involves frequent open meetings and large public artworks stating opinions and intent (Han, 2008). This process warrants further exploration, as it is understood as being in a dialectical tension—between the organisers, who might hold responsibility over prosecuting change, and the community who must support and resource that change in order for it to succeed. Here, the value of leadership is expressed through the community around it, who must direct leadership to serve them. If we, as leaders in innovation processes, designers and researchers, want to express collective agency in our work, we need to tell our communities that ‘it is right to rebel’.

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Bags of Value: The Value of Design against Crime Interventions

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This paper draws on valuation studies to reveal the valuation work done by a designer who can see how to make a design against crime initiative for a new store carrier bag, valuable to a UK retailer. While design interventions have proven to have a positive impact on crime reduction, designers have often struggled to justify the value of their work a priori (Ceccato, et al., 2018). When designers fail to do this, managers in a complex and dynamic organisational setting, typically neglect to access resources and secure the necessary commitment required to commission and put into practice design interventions that have the potential to deliver both social and economic value. Drawing on an ethnographic study this paper maps out the work that needs to be done by designers to equip retail managers with tools that calculate the value of design. In so doing this paper makes three key contributions. First, it contributes to the design against crime literature revealing that both where social and economic value sits at each stage of the design process- this seems critical to moving a design intervention forward step-by-step. Second, it reveals how the moment of valuation inform and unfold the design process, enabling the actors to collectively calculate the most appropriate way ahead for their concerns in action. Finally, how a simple tool such as a store carrier bag can help shoplifters and how design against crime method can convert it to a crime preventive tool.

Keywords: Design against crime interventions, Valuation tools, Value

1 Introduction

Retailers face the significant challenge of trying to prevent retail crime; in 2017 UK retailers lost £700 million worth of products to shoplifters (British retail consortium, 2018). In recent years, a design movement, known as design against crime, has taken a deliberately interventionist approach to crime prevention, arguing that design intervention offers opportunities to decrease the occurrence and impact of crime through the application of design practices to products, services, strategy, and environments (Davey et al., 2017). The design against crime movement has made significant strides in developing design against crime methodologies. It began in 1999 with a joint initiative between the UK Home Office, the Design Council and Department of Trade and Industry and has been developed by Lorraine Gamman and colleagues at the University of the Arts London (ual) and Central Saint Martins in London (Davey et al., 2003), and is grounded in three ‘design thinking’ principles. First, human-centred innovation processes underlie design against crime practice – beginning with observation, then the visualisation of ideas, concept prototyping, alongside concurrent business analysis, generative innovations and creative ways forward for those seeking to

address organisation and managerial problems (Lockwood, 2009). Second, the approach is premised on collaboration. That is, drawing on the expertise of different actors – designers, criminologists, security personnel, managers – brought together in collaborative engagement to work collectively on the creation of a solution, third, and more specifically, the design approach should take into account 'users' as well as the 'abusers' needs (Gamman et al., 2006). In other words, the purpose or object of the design intervention frames the entire process. Thus, design against crime offers a useful and valuable methodology for retail managers seeking to protect their stock and limit their losses from shoplifters. Yet such interventions can represent significant investments for shop floor managers and can be seen as 'costs' that are hard to justify by retail headquarters, particularly when headquarters have already invested in the design of shop architectures, floor layouts, and fixtures and fitting. This presents a key challenge for designer. If designers are not able to persuade or equip managers to calculate potential savings or lose prevention, then commissions for design interventions are at best unlikely to enable crime reduction and at worst are inconceivable for managers and crime prevention investors.

Recent design research has begun to recognise the role of value in the commissioning and evaluation of design in practice. In the design against crime literature the different forms of value that design against crime can generate are often cited (Whitham et al. forthcoming). For example, architectural design offers aesthetic value attracting customers to an interesting looking store, while designed environments can offer social and economic value, making a community feel safe and reducing the cost of law enforcement (Whitaker, 2011). Yet as extant studies have shown that even when managers know that such interventions can save their store from significant shoplifting losses, they still fail to invest (Ceccato, et all., 2018). The design literature does little to help managers understand the different forms of value that may become clear at different and some late stages of the design against process.

This paper draws on the sociology of valuation literature to explore how designers better equip managers with key ways of calculating value at different points in the design against crime method. We set out to identify how the practices designers perform in situ come to make certain things, experiences or types of intervention valuable: socially and economically (Kornberger et al., 2015). Findings of ethnographic study of a design against crime intervention in a UK premier retail store – referred to here under the pseudonym HSR (High-street Retailer) - to map out key 'moments of valuation' (Antal et al., 2015) that emerge from through the design against crime process. The designer can see how to intervene in design against crime interventions to prevent, or at least deter shoplifting. Working ethnographically with security and sale managers to observe and analyse shoplifting practices managing to reduce shoplifting crime, this study maps out the valuation practices that frame and make valuable a design against crime interventions to store managers: the sealable bag.

2 Literature Reviews

2.1 Design against Crime

There are several historical cases of design being used for security improvements, such as castle walls and arrow slits. Also, North American researchers have started studying the relationship between the design of the built environment and the opportunity for criminal

activities in the 1940s. As a result, the ‘opportunity’ is considered to be a core factor in the incidence of crime (Davey et al., 2017).

According to the design council, ‘crime brings with it a cost to individuals and business in three ways: Cost of anticipation of crime, Cost of the consequence of crime, Cost of responding to crime’. Also, for each person, the cost of crime can embrace time off work because of the damage to a person's body, as well as feelings such as anxiety, stress, feelings of defencelessness and decreased self-confidence. Crime has extra costs for organisations, such as local and national authorities regarding police time and the cost to the national health service and other public services. (Design Council, 2017).

Design against crime initiated in the United Kingdom is intended to improve crime prevention by using the designer’s ability to reframe issues inventively and to develop creative, practical solutions without enlarging the fear of crime. Therefore, the outcomes are less susceptible to crime as they are developed through a significant and robust design thinking process (Davey et al., 2017).

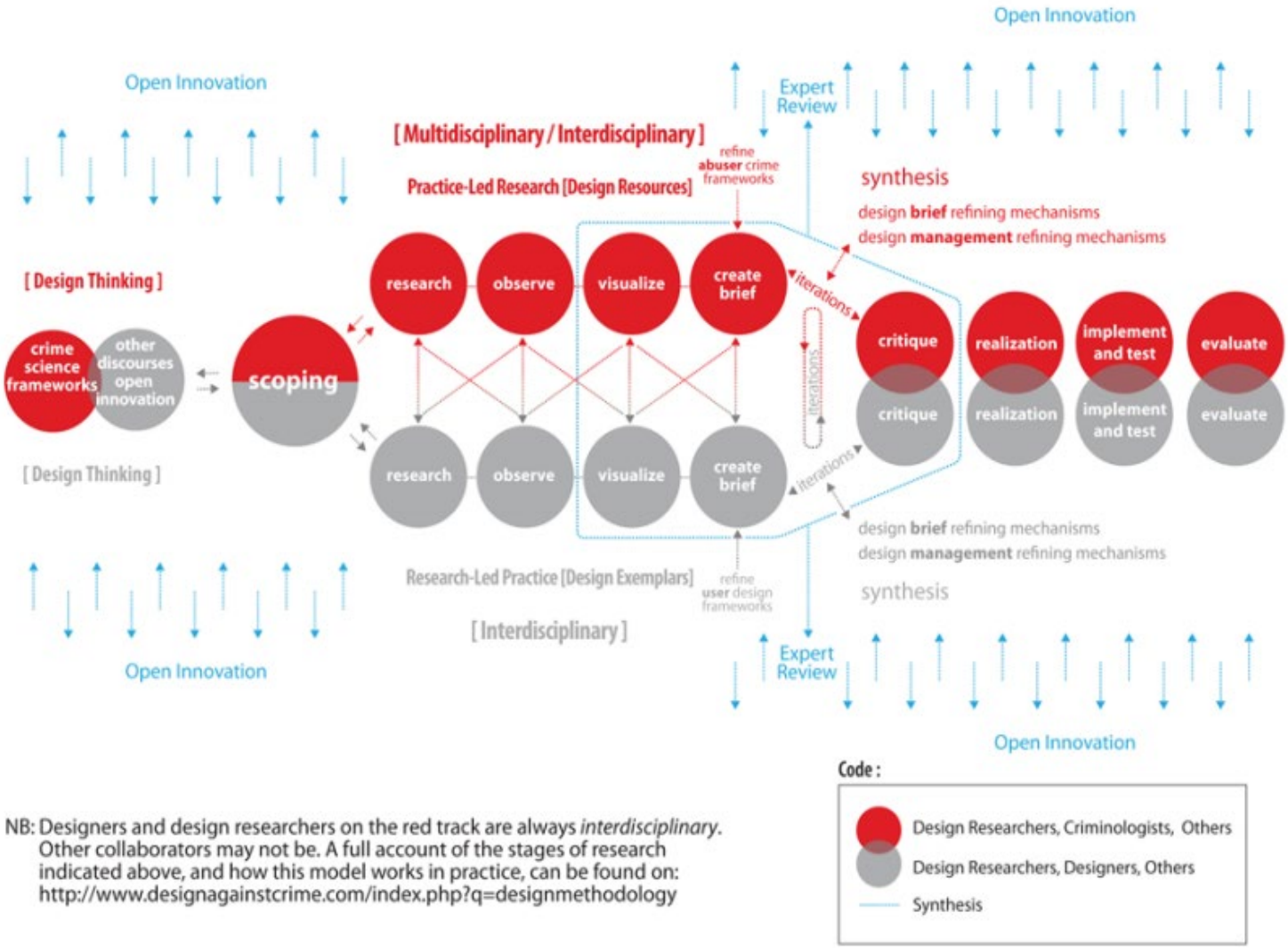

Figure 1. Design against crime evolved twin track model of the iterative design process. Source: ual 2006

Designing against crime is a relatively new method to reduce crime and the damage from criminal actions through designing a creative service, strategy, educational and learning package, environment or product that is appropriate for the situation (Gamman et al., 2006). This method emerged in 1999 out of the UK Home office, design council, and department of trade and industry. It is a practice-based design research development that appeared later at Central Saint Martins in London (Davey et al., 2003). Design against crime as a UK initiative tries to improve ordinary and regular security mainly by focussing on crime prevention (Davey et al., 2017). Through the design against crime process and thinking, designers need to consider prevention at the starting point of a project; therefore, they can prevent crime from happening, or reduce the opportunities for criminal behaviour (Home office, 2010). There are different approaches to design against the criminal thinking process. As an example, the figure below explores the twin-track approach model of design against crime thinking that has been suggested by Gammon and Thorpe in 2006.

According to the model, the team use the approaches which are related to their design thinking process to stay focused on their questions and to identify the zones where they want their tasks to be undertaken. Their scope is related to open innovation as a wide range of approaches. In this stage, they have intricated emerging and developing ideas. The research starts once the project triggers and the design researchers, crime experts and other researchers collect and contribute data and information. However, the designers are usually interdisciplinary in their approach. The team does ethnographic observations to learn about the users and abusers' behaviour and issues. Therefore, all information gets reviewed and discussed. By visualising the findings, the interdisciplinary approaches can be composited, and designers can redefine the design brief. In this stage, whole team members are engaged in critique sessions and start making decisions about the best way to prototype the concept. Testing is the next stage which involves user and abuser feedback. The final stage is to evaluate to assess the quality and results of the functionality of the design. The whole process is iterative (ual, 2006).

Design against crime is not UK-based only and other research centres across the world has done valuable research methods in design out crime, for instance**,** Designing Out Crime research centre (DOC) who is a partnership between the NSW Department of Justice and the University of Technology Sydney in Australia is using 'Frame Creation' to find the problem behind the problem. By this innovative tool, they investigate issues in-depth to grasp it before anticipating solutions (UTS, 2019).

2.2 A Sociology of Valuation and the Valuing of 'Design Against Crime'

Valuation practices can be understood as the practices that make things socially and economically valuable (Kornberger et al., 2015) and their outcomes – value(s) – are seen as the objects used to make judgements and calculations about what could be done and what is worth doing in future (Lamont, 2012, Stark, 2000, Antal et al., 2015). As such valuation practices are becoming an increasing focus of market studies, particularly in relation to the process of making new things and processes valuable (see for example, Mason et al., 2018, Kjellberg et al., 2013), and in the calculation of value such as that represented in prices, in retail settings (Hagberg et al., 2015). Valuation practices then, are the routine and recursive practices that collectively determine how new goods are conceptualized, produced and exchanged, as distributed actors with different forms of expertise and valuing systems, come together to work out, and often contest what is worth doing, how (by whom) and why (Araujo et al., 2015, Dussauge et al., 2015, Stark, 2000).

Kimbell and Julier see value in terms of the performance of measures in the generation of value, asking to what end, and how measure makes things or courses of action valuable in

their account of social design practice in the context of UK measurement and evaluative regimes. Audit culture, bureaucracy and management practices are taken to represent a space of incoherent and competing demands for evaluation, observing that “assessing the ‘value’ of social design research requires one to be aware of the tools, practices and infrastructures through which valorisation is practically achieved”. This has important implications for where a design researchers’ attention might be usefully directed to understand other contexts, specifically for how designers might work out how to make their work valuable in a retail crime context.

Related research has reinforced the importance of cultivating and attending to the values of design participants and other stakeholders in collaborative design work developed practical methods and resources for doing so and investigated the value of designers’ creative practice within collaborative work and , as the attention of design has broadened from artefacts to systems to services, conceptualisations of value from other disciplines such as Consumer Culture Theory and Service Dominant Logic (Vargo et al., 2008) are being utilised in developing design practice that understands how value exceeds top-down articulation. Such work considers value within the frame of design practice - how value is understood, generated, and employed in design situations. In this regard, both social and economic value(s) are implicated in the valuation of design.

The study of valuation practices in design against crime context then is the study of how things are made commensurate, compared, categorized, and clarified (Lamont, 2012, Kimbell et al., 2018); of how some things are judged to count more than others. It is through valuation practices that the management of a store and its retail practices are ordered, hierarchized, and ultimately valued (Kornberger, 2017). This seems particularly pertinent in uncertain retail crime settings where the anticipatory nature of design and retail crime activity requires a pragmatic approach to working out what is plausible and what investments should be pursued next using what tools. The tools used in these valuation practices vary, depending on which actors invoke them and why; we consider these next.

3 Empirical Context and Background

3.1 British Retailing and Shoplifting Statistics

Retail crime is one of the most frequently committed crimes in the United Kingdom; since the 1800s, England has become an industrialised country and experienced extensive urban growth, sales associates have chosen this location to establish large stores. Towards the end of the nineteenth century, the aim was to create stores to induce customers by space design. The customers could touch the goods and they were not accessible only through the retail assistant anymore (Whitaker, 2011). Since then, due to this new differentiation, retailers have been experiencing a significant change in their customer’s behaviour; there are some restrictions on this new strategy that afford excellent opportunities for shoplifters and opportunist criminals (Ebster, Garaus 2011).

The statistic (Statista, 2019) shows the number of police recorded shoplifting offences in England and Wales from 2010/11 to 2017/18. For most of this period the number of shoplifting offences has fluctuated, but from 2013/14 onwards there has been year-on-year increases, peaking in the most recent reporting year at over 382 thousand offences (Statista, 2019).

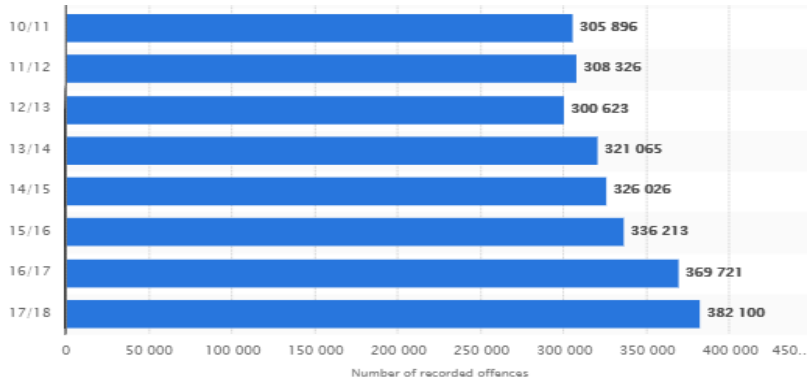

Figure 2. Shoplifting statistics by number of incidents. Source: Statista, 2019

Moreover, because of the promotion of sales by product accessibility strategy, 'HSR' is a comfort shopping zone where creates a fantastic target and environment for shoplifters' activities. Therefore, this paper focuses on criminal activity in retail environments to reduce preventable losses and retail shrinkage within design thinking through a creative solution. Furthermore, the outcome will be valuable as the economic output of the retail sector in terms of Gross Value Added, GVA, in 2017 was £92.8 billion, which was 5.0% of the UK's total GVA (Arhodes, 2018)

3.2 The Politics of British Retail Crime Prevention

Crime is an expensive and daunting issue influencing organisations and individuals. The victims of crime experience injury, financial loss, fear and pressure. Crime prevention is a possible technique to control and manage crime (National Crime Prevention Institute, 1986).

Retailers need to be more sensible about crime and loss prevention. However, they share ideas with other retailers to limit crime. Also, they collaborate with the police, government, local government and local crime reduction agencies. Retailers are determined to convince the police and the Home Office to put a greater emphasis on retail crime (Bamfield, 2012). According to Wootton (2015), as police left with the short budget it has increased pressure on them, so their focus is on issues which damage lives mostly, and retail crime is not their priority. Retailers need to take responsibility and think about their issues directly, and instead of policing and arresting shoplifters, they need to prevent or reduce crime (Ebster, Garaus 2011).

4 Methods

To discover how designers equip managers with key ways of calculating value at different points in the *design against crime* process, a case studies approach adopted (Yin, 2006) in a single premier retail store – referred to here as 'HRS'. Focusing on shoplifting in a single store enables researcher to work within clearly demarked boundaries. Data was collected using ethnographic methods: observations, interviews, workshops and organizational documents and archives (Yin, 2006). Observing and collecting the micro-level data enable researcher to identify the valuation practices that were being performed and track the involvement of employees who are in working for loss prevention in the store: security manager, operational manager, sales manager and store manager. This provided researcher with the detailed data to intimately connect to the context and the practices of observing shoplifting crimes (and how these crimes where observed and managed by the store) and observing others working to prevent shoplifting. Such an approach is particularly effective in enabling researchers identify and unpack the complexities of often hidden or unnoticed everyday practices and engaged the researcher in an introspective and reflexive process to produce data (Kjellberg, 2017).

Data were analysed at each point of the design against crime process (Figure 1). Ethnographic method and being critical enabling the research to use systematic combining and abductive reasoning to unfold the project and navigate between the world of theory, design and practice opening a continuous interplay between theory and empirical observation. Observation field notes and diaries were analysed first to construct a rich picture of the shop/shoplifting setting, identifying key actors and their behaviours, practices and relations. Next, qualitative data was used to identify core issues: when how and where shoplifting took place, if and how it was dealt with by whom, and how shoplifting loss was calculated by the store. Focused interviews 'HSR' staff was conducted to have direct interaction with the contributors. Their opinions were collected based on their knowledge and constructed a book of vignettes that recounted their experiences of observing and dealing with shoplifting. This ethnographic process leads to the decision to redesign a store carrier bag as the result showed that the bag is a great tool for shoplifters, but further valuation practices had to take place to ensure that the 'bag project' went 'live'. Prototyping is now being engaged with by the designer/author in HRS. The first prototype was produced to enable HRS employees to engage in the design process (Hanington et al., 2012).

As interviewing offenders could be risky and inconvenient, the researcher studied their behaviour and methods by observing them in the store control room through CCTV cameras and had an informal chat with the detained volunteer ofernders.

5 Findings and Analysis

The design against crime process has been mapped out as figure below and through observations and analysis identified distinct valuation practices and moments of valuation that occurred at different stages of the process.

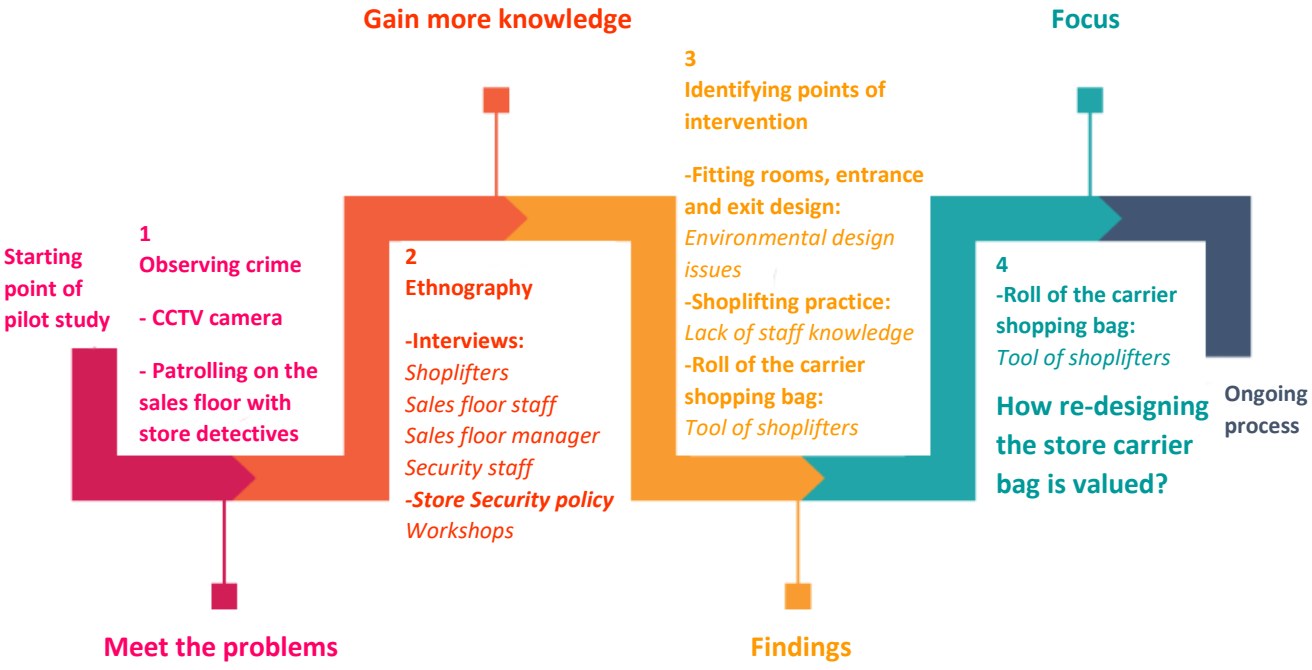

Figure 3. Methodology. Source: Authors own

The researcher paid attention to extant design features of the store – the store layout and how it configured action. The HSR is 155,000 sq. ft in three levels. The store has three fitting rooms. Early interviews identified the fitting rooms as a key site of shoplifting. Observations

began with the ground floor fitting room which is one of the largest fitting rooms in the store. According to the security staff, this place is one of the main places targeted by shoplifters: its design and layout was said to create a 'comfort zone' for shoplifters. The observations revealed that shop floor workers and security staff had concerns about how customers entered and exited the fitting room, how the 'privacy' of the fitting room generated opportunities to hide merchandise 'ready for nicking'.

The researcher gradually rolled out the scope and scale of observations to the different departments and sections. It was observed how store and fitting room layout and design functioned as an opportunity for shoplifting. The researcher worked with the instore security team to understand the security aspects that concerned them and talked to floor staff to understand their activities and customer serving practices, and the roles these took (if any) in preventing retail theft. The researcher wanted to know how the staff adhered to 'store security policy' and how the customers and shoplifters behaved during their shopping process. Three key sites of practice were identified: shop floor (particularly around certain key types of shop fittings), fitting rooms and till banks. Tables 1 and 2 below highlight key observations of common body language and shoplifting practices.

Table 1: Observational data Analysis 1, 12th – 17th August 2018.

Common Shoplifters' Body Language
Watching CCTV camera and staff
Going to the fitting room slimmer and coming out bigger with bulky clothing on
Looking at random easy concealable items and moving to different departments and levels
Coming in to the store with an empty plastic bag in hand
Hanging around with a baby in a large pushchair with lots of stuff all over the pushchair
Coming in to the store in winter time with no coat or jacket on
Holding their hand bag half open on their shoulder ready to conceal products
Going back to the fitting room with the store carrier bag after purchasing some products
Keep moving around the store to find an empty store carrier shopping bag that is left on the floor by another customer

Source: Authors own

Table 2: Observational data Analysis 2, 12th – 17th August 2018.

Common Shoplifters' Practices
Selecting good, taking them to the fitting rooms, returning them to the tills as faulty to obtain refunds for stolen clothing
Concealing items in their pocket, own bag or a shopping bag, push chair, wheelchair
De-tagging, exchanging a sale ticket with a full price ticket
Selecting a new item and taking it to the fitting room, wearing it on, coming out and return their old item to the sale assistant
Selecting clothing, removing hangers and rolling the item to conceal
Paying for 8 cheap items, going to the fitting room with different 8 expensive items with the store carrier shopping bag, swapping the items and returning 8 purchased cheap items to the sale assistant

Source: Authors own

The result of observation and interviews with the sale staff shows that store carrier bag is a tool for the shoplifters (Figure 5).

Figure 5: Current Store carrier bag. Source: Authors own

The case below is one of the examples of misusing the store carrier bag. The images explore that the shoplifter using the store carrier bag to conceal packed products. Researcher was observing the shoplifter and noticed that he entered the store and found an empty bag on the floor and went towards the target speedily and steal what he wanted. The process was very fast, and the shoplifter exit the store before camera room security staff complete his communication with the guard at the store entrance.

Figure 6: Using store carrier bag for shoplifting. Source: Authors own

The issues related to the HSR carrier bag made researcher to investigate the design of the bag and the technique of the shoplifters to find out how to rectify the issue. She used the same technique to understand the process and found out how convenient it is as she stole £90 products within less a minute.

Figure 7: Investigating shoplifting technique Source: Authors own

By confronting the store managers and security staff with the observational data, the process of observing, speaking to, assembling and representing data as part of the design process was made valuable. Managers and security guards were often aware of patterned practices but got extra value from seeing the presentation of data in a tabular format. Getting a sense of the scope and scale of shoplifting losses was also meaningful to them, with one manager commenting ‘we know exactly to what extent this is a problem’.

The researcher used the observational data to argue that one of the most cost-effective ways to intervene in the shoplifter’s practices would be to redesign the bag. Here the designer made an explicit connection between the social issue that is of value to the group (preventing shoplifting), the observational data that shows that bags play a key role in shoplifting, and the economic value of a design intervention – ‘redesign the bag is quick and easy to do, is low cost and is easy to put into action, and goes on to use this in our case to persuade the retail manager that the design effort is worth it arguing.

6 Outcomes

6.1 The First Concept

The first idea is to seal the bag after completing the transaction on the cash points (using sticker, integrated on the top of the edge) to stop shoplifters concealing products.

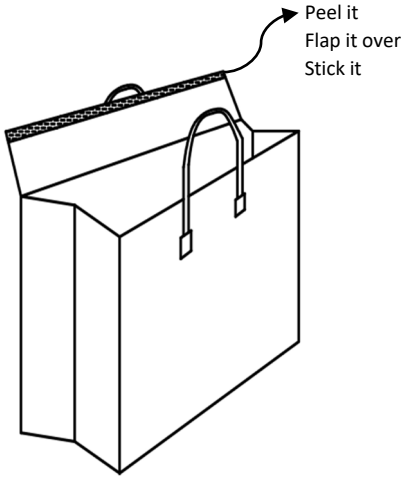

Figure 8: The first concept – Sealable bag with sticker. Source: Authors own

Even though the asset protection management team were satisfied with the concept, as this concept has extra material on the top including the paper and sticker, they claimed that the concept makes extra cost and as company has limited budget, they cannot invest money on this concept. Also, when we were testing it we found out that it is not easy to flap the paper over because of the handles. Therefore, the second concept has been introduced as over.

6.2 The Second Concept with Two Edges

The idea is to put the flaps together and fold them over to seal the bag. Also, a small sticker can be used which is optional (the blue sticker on the image below).

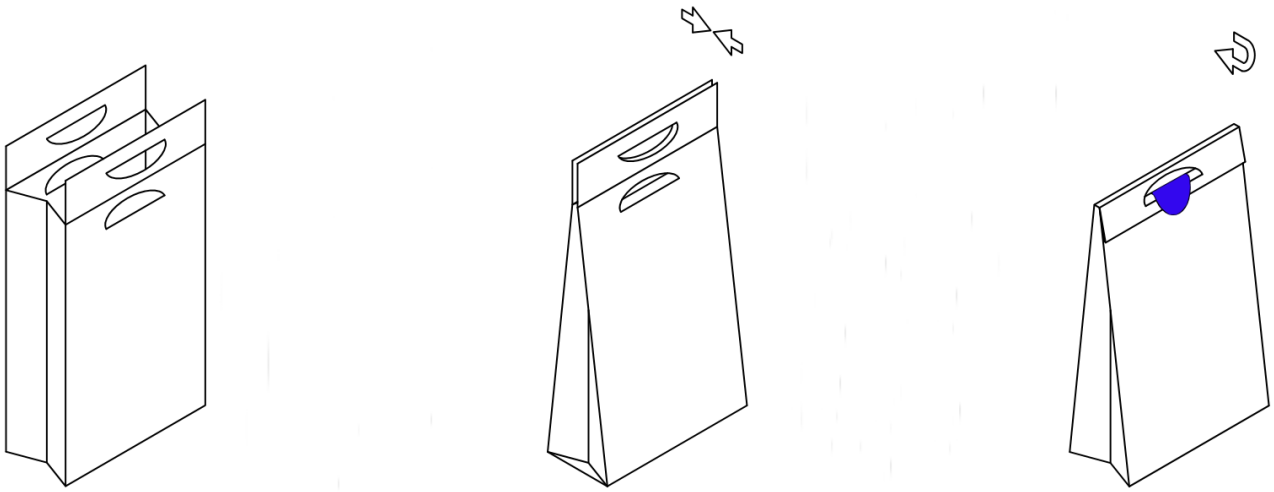

Figure 9: The second concept – Sealable bag. Source: Authors own

The concept was prototyped as below (Figure 10), and researcher noticed that one of the flap can be removed (Figure 11). Also, using the blue sticker is not necessary as it is an extra cost and the concept is sealable enough.

6.3 The second concept – Quick Prototype

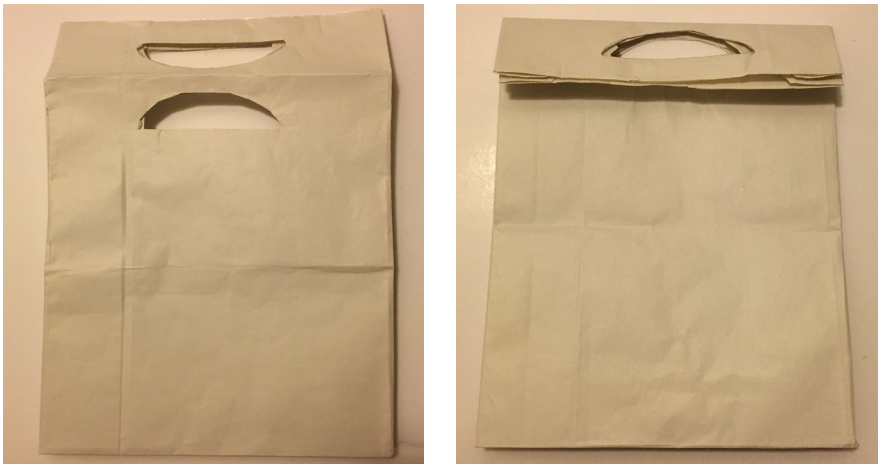

Figure 10: The second concept – Prototype. Source: Authors own

Therefore, the third concept was produced as over,

6.4 The third concept with one tail

This concept has been accepted by company's asset protection team and has gone through for the costing stage and final decision. Mean while more testing will be conducted with staff and customers and the result will be sent to the asset protection team. The next stage will be explained next.

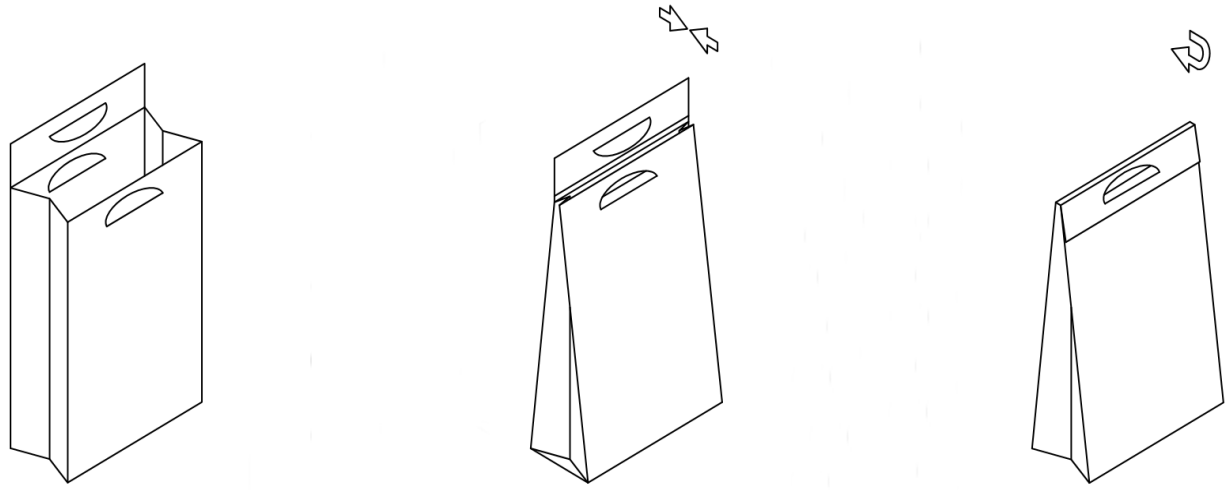

Figure 11: The third concept. Source: Authors own

6.5 The Third Concept – Prototype and Usability Test

Figure 12: The third concept – Prototype. Source: Authors own

The next stage is to produce 50 bags (Figure 12) and test them with different users with small and large hand. Also, use them on the cash points and observe how our retail staff get along with the new concept while they are serving the customers. This allows researcher to observe their reflection and rectify the issues. Also, it is important to see how customers will react to the new bag. Researcher will train staff beforehand to explain to the customers that how the

new concept is socially valuable as the customers carry it comfortably. Also, it will be more reinforced in wet weather and the products are preserved for the customer.

One of the issues with the current bag is that they are not strong enough when it is raining, and customer asks for two bags to leave a filled bag to anther empty bag to make it stronger.

6.6 The Cust of the Current Bag

Table 3: Cos of current bag.

Costing	
Style	Handle Paper Bags
Print	1 Colour (Average Ink Coverage)
Size	300 (w) x 125 (g) x 400 (h) mm
Material	80 gsm Brown Paper
Quantity/Price	20000 @ £115.00 Per 1000

Source: HSR, 2019

The asset protection management team suggested that if the manufacturing of each bag cost two pence more than the current cost, the spend would be about 3 million pounds more. However, we are losing ten million pounds a year through retail crime in the company. Therefore, it seems that even the new concept manufacturing cost more, it is still valuable economically for the company to go for it.

7 Conclusions and Implications

This paper made use of the valuation literature as a lens to explore how designers better equip managers with key ways of calculating value at different points in the design against crime process. We identified a four-stage process before the judgement point that calculates what is to be designed. That is, observations with and of staff working to prevent shoplifting is used to show that there is social value – and collective social concern (i.e. what matters also counts) – and so a particular problem becomes calculated as worth doing something about (Antal et al., 2015, Stark, 2000). By equipping managers with tables showing categories and quantities shoplifting crime, a designer can show value in action. Next the designer uses additional corroborating data to enrol and mobilise the group in identifying and calculating the object of design – in this case a bag that could make shoplifting more difficult – as a design effort they can ‘buy in to’. Researcher then reassemble the data, combining it with achieve data (what has the company done in the past) and documentation that shows the retailers ‘security policy’ as a framework to guide action, and further calculate what should be invested in and why. Finally, the ‘shopping bag’ design effort is collectively judged worthwhile and the product design process begins attaching costs and improvement that make the bag easy to use into their calculations. At each stage key *moments of valuation* move the project forward. Mapping valuation practices onto the design against crime process makes three key contributions to the literature.

First it contributes to the *design against crime* literature revealing that both where social and economic value sits at each stage of the design process- this seems critical to moving a design intervention forward step-by-step. While Gammon and Thorpe (2006) have developed a valuable process for design against crime initiatives, there work says little of the challenges to persuade those with little money to spend, to spend it on valuable design interventions. The paper draw on a growing interest here in the value of design (see for example, Kimbell et al., Whitham et al. forthcoming) to show how each step of the design process can be used to equip managers and co-designers with ways of calculating both social and economic value for the project at hand.

Second, it reveals how *moment of valuation* (Antal et al., 2015) inform and unfold the design process, enabling the actors to collectively calculate the most appropriate way forward for their concerns in action. Co-design is positioned as a key element of the design against crime process and moments of valuation offer valuable insight into how such collectives are move forward step-by-step as they develop and make use of different valuation systems and orders of the security people, the managers, the shop floor staff.

Finally, the paper generates some insight into what the different crime preventive and calculative tools might look like (see for example, Azimont and Araujo, 2010, Callon and Muniesa, 2005). This is new for the design process and so in a world where economic value is barely spoken of, and where the ramifications of it being ignored are significant, it offers a new avenue for further research. There is much work still to be done to understanding how designers typically produce calculative tools that help actors work out what is worth doing next in the design process. Further, if there is anything particular about the design against crime process here, that has taken into account, in this instance the backdrop of retail crime statistics and concerns in the UK. The study was a single site study and falls short of the scope of this question. But this marks an important opportunity for further study.

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Design Subject Setting and Design Competition Practice

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Many studies have pointed out the importance of design resources for innovation. For example, design competitions are held by companies to introduce external design resources to accelerate innovation and development. However, are competition subjects setting and governance aligned with organizers' expectations regarding innovation? By studying the Thermaltake Creative Design Competition for eight years and combining literature reviews, empirical research, and expert interviews, the authors of this paper explore how to set subjects and discipline to make competitions as innovative method that companies need. The findings indicate that: 1) the subjects (i.e. themes) of design competitions should be based on the company's expert product categories, which can be "narrowly focused" or "broad"; 2) two stages of assessment will help the company to scan and rate suitable design proposals, and the set-up of juries consisting of internal experts with industry background in the preliminary assessment stage and external experts in the final assessment stage is important to increase the feasibility and keep the diversity of design proposals; 3) communication and collaboration between the company and participants are beneficial for both parties. The technical seminars held by organizers will promote in-depth communication and improve proposals to be more in line with expectations. This study puts forward some practical and theoretical findings in the field of innovation management, which can be a reference for enterprises using design competitions as an innovation design method.

Keywords: Design competition; Innovation method; Design resources; Design subject

1 Introduction

Enterprises are facing the rapid development of technology and shorter product life. As organizations struggle with a persistent mismatch between the innovation resources at their disposal and the demands of a rapidly shifting environment, they increasingly turn to external resources, such as technology brokers, project promoters, and innovation intermediaries, as a way of complementing their internal innovation process (Neyer, Bullinger, & Möslein, 2009).

Chesbrough (2003) proposed the concept of Open Innovation in 2003. He suggested that companies should not be limited to internal R&D resources, but should cooperate with external partners to innovate. Design competitions fit well into this trend, which is one reason they are being used more frequently today. According to the design competitions listed by the Ming Chuan University, there were 25 creative product design competitions sponsored by companies in Taiwan in 2015 alone (Ming Chuan University, 2015). There are many practical cases of companies holding creative design competitions as a platform for

innovation. The growing popularity of design competitions suggests that they are a firmly established innovation strategy (Lampel, Jha, & Bhalla, 2012).

Although the use of design competitions to access external innovation resources is not new, the increased power that comes with combining this approach with the rich innovation ecology has just emerged over the past several decades. An additional change in current design competitions is the emphasis on collaboration (Love & Hubbard, 2007).

There are various purposes for companies to organize design competitions, as well as different structures and governance practices. Some companies have held design competitions for many years, but some have stopped due to limited results. The serialised competitions delivered by dedicated juries give sponsors greater opportunity to learn and refine the architecture of such competitions, while also improving the alignment of participants' motives with the objectives and interests of the design competition, as well as the organizing and sponsoring institutions more generally (Lampel, Jha, & Bhalla, 2012).

This paper is based on design competition theories and the study of the Creative Design Competition sponsored by the Thermaltake Technology Co. Ltd (hereinafter called Tt Competition and Tt Company), a serialised competition which has been held for eight years. It is a good case to study to explore how to use a design competition as a platform to achieve creative results. Through an analysis of their results and experiences in holding design competitions, we can determine effective applications of competition architecture and governance methods and expand the current research of design competition management to the event evaluation phase.

The Tt Competition explored in this paper has been held for eight years and refined over time. The authors has been involved in all these events, beginning as an organizer in the first two years and then shifting to collaborating institutions, and has been studying it for six years. Therefore, the author is familiar with every phase of the competition and recognises it from different perspectives, from the sponsors to the jury to the participants.

1.1 Design Competition: Purpose and Components

As an innovation method, a design competition is a type of "search" strategy (Banerjee & Loukaitou, 1990). Earlier in 1987, Alexander, Whittling and Casper (1987) showed that there is a clear difference in the organisation and use of "concept" versus "implementation" competitions. With demands on product innovation concepts, some companies use design competitions to convey their innovation values and policies, such as the "Great Design Competition" held by GIGABYTE since 2003, while others explore potential new product ideas in design competitions and transfer winning entries into commercial products, such as Japan's KOKUYO Design Award and Ilan Chair Design Award.

Nasar (1999) described design competitions as open competition, limited competition, invited competition and two-stage competition. Through competitions, the organized institution could identify potential designers or feasible design proposals. Paul Spreiregen (1979) listed the benefits of holding design competitions including: discovering unrecognized talent, producing new solutions and bringing attention to or publicizing architecture.

Design assessment methods can generally be divided into sequential assessment methods and quantitative assessment methods (Baxter, 1995/1998). Chen (2004) has divided design conception evaluation decisions into two stages, namely conception scanning and conception rating. Scanning is a quick and concise assessment of some feasible

applications. Rating is a more careful analysis of these shortlisted ideas to choose the most successful design solution. Banerjee (1990) has mentioned that the composition of the jury of a design competition should be diverse rather than uniform. Each jury member has his own perspective on design criticism. Therefore, the design juries should consist of multidisciplinary and unpredictable perspectives, not one “line of thought”.

1.2 Design Competition: Subjects and Goals

Füller, Hutter, and Faullant (2011) introduced the “virtual design competition” as a new means of opening up the innovation process and enriching companies, and Lampel, Jha, and Bhalla (2012) have explored the competition phenomenon according to the development of open innovation, showing the relationship between innovation agendas and design competitions. The agendas rooted in immediate concerns and future aspirations shape the competitions’ goals and process. They believe that design competitions with narrowly-focused innovation agendas provide innovative solutions to business problems, and they are often applied by companies which lack resources and have an inflexible administration, or which consider the projects’ cost inside and outsourced.

At the opposite end of the spectrum, design competitions reflecting broad innovation agendas accelerate or even reshape market development. Design competitions with broad goals are more likely to motivate technical innovations and overcome the bottleneck of innovation. Innovation agendas in this case are often influenced by strong conviction that certain markets that ought to exist do not, or if they do exist they should evolve in a different direction (Lampel, Jha, & Bhalla, 2012).

1.3 About Thermaltake Company and its Product Innovation

The subject of this case study is Thermaltake (Tt) and its creative design competition. Tt Company was established in 1999 and became a listed company in 2007. Since its establishment, the company strategy has been to build its own brand and keep innovating products. It has the capability and experience for innovation research and development. The company has a Creative Design Centre, Engineering Department, Marketing Department, and Business Department. Its Creative Design Centre is in charge of industry design. In addition to using its internal design department, the company also takes an active part in cooperating with external design resources on new product design concepts and new product development projects.

Tt Company’s product lines include computer chassis, CPU coolers, power supplies, and other computer accessories. Due to the wide range of products, and in order to maintain its market competitiveness, the company needs continuous innovative product development, which needs to be nourished with a steady stream of innovative product ideas and concepts. Aside from the new product proposals from internal design departments, the company began to cooperate with BMW Designworks USA in 2009 to develop the new computer chassis, Level 10 (Figure 1). Once the product launched, it received many international design awards, such as IDEA and Red Dot. Based on this good experience of collaboration with external design resources, the company started to continuously seek new product concepts from external design resources to accelerate its innovation development and show its positive image for innovation.

Figure 1: Computer Chassis Level 10. Source: Thermaltake Technology.

2 Research Methods

The research methods for this study are divided into two phases. The first phase is the data collection and data analysis of the Tt Competition. The second phase is the expert interviews with the relevant personnel involved in the Tt Competition. Furthermore, an analysis of the results and suggestions are presented in this case study.

2.1 Tt Competitions Data Collection

The data collection section includes the background of Thermaltake Technology Company and materials from the first to the 8th Tt Competition, covering the competition introduction, objectives, theme settings, entry assessment, and competition results. The collected data were then analysed to understand the company business strategy and how the Tt Competition is executed, as well as the results of the competition. Data collection items and content are presented in Table 1.

Table 1 Data Collection Items and Content.

Item	Competition related	Company related
Competition objectives	1.Competition introduction 2.Competition governance methods explanation	1.Business strategy 2.Company creative strategy
Subject setting	1.Competition subject setting process 2.Competition subjects	1.Company product lines 2.Company product development road map
Entry assessment	1.Competition judging process 2.Jury setup 3.Judging criteria 4.Quantity of competition entries	N/A
Competition outcomes	1.Creative concept application 2.Design proposal commercialisation	Feasibility evaluation process

2.2 Expert Interviews and Discussion

The second phase of the study was interviews with the sponsor and organisers. The interviews were conducted as “semi-structured interviews”. The goal of the interviews was to

collect the organisers' feedback and evaluation of the competition. The interviewees were required to have participated in two or more creative design competitions. The interview time set for each interviewee was 30-50 minutes. Interviewee details are listed in Table 2.

Table 2：Interviewees and their Positions

Department	Position
Board of Directors	CEO
Project Team	Project Director
Creative Design Centre	Design Manager
Creative Design Centre	Senior Designer
Business Department	Marketing Manager
Business Department	Product Manager

The expert interviews were accompanied by a questionnaire, including close-ended questions and open-ended questions to state personal opinions. The content of the questionnaire is listed in Table 3.

Table 3：Questionnaire of Expert Interviews

Questionnaire of expert interviews		
A. Performance of design competition		
A-1	What are the objectives of the competition?	Public benefit
		Brand promotion
		User comprehension
		New concepts
		Other
A-2	Have the objectives been achieved?	Public benefit
		Brand promotion
		User comprehension
		New concepts
		Other
A-3	What is your advice on how to improve the performance?	
B. Competition subject setting		
B-1	How is the competition subject set?	Demand on new product development
		Customer demands
		Investment cost
		Technical advantages in R&D
		Other
B-2	Does the competition result match the subject setting?	Demand on new product development
		Customer demands
		Investment cost
		Technical advantages in R&D
		Other
B-3	Achievement of broad competition subject	Innovative design porposal
		Reduce innovation costs
		New technology exploration
		New market direction
		Other
B-4	Achieving the goal of narrowly-focused competition subject	Innovative design porposal
		Reduce innovation costs
		New technology exploration
		New market direction
		Other
B-5	What is your advice on how to set the competition subjects?	
C. Competition assessment		
C-1	The appropriateness of the competition judging process.	
C-2	The appropriateness of the jury setup.	
C-3	The judging criteria.	Design concept
		Product market
		Feasibility
		Other
C-4	Do the winners meet the expectations?	
C-5	What is your suggestion for the assessment?	
D. Post activities of the design competition		
D-1	How to deal with winning works	New product development
		New product development
		Discover talented designer
		Other
D-2	Adjustment of competition principals based on competition results	Design sujects
		Assessment jury
		Judging criteria
		Competition governance
		Other
D-3	What is your suggestion for Post activitie after the competition?	

The following discussion is based on understanding the collected data and comparing the feedback and suggestions from the expert interviews. Through analysing the relationships between planning and the results of the Tt competition, including theme setting, entry assessment, and how to deal with the competition outcomes, it is possible to learn lessons from Tt Company's experience in holding a design competition.

3 Tt Competition's Data Analysis

3.1 Thermaltake Creative Design Competition Introduction

In 2012, Tt Company held the first invitational design competition, which was carried out in two universities. It was titled "The Wishful World of Computer Gamers, Creative Design Competition". The initial purpose to hold the competition was the public benefit, while also enhancing the company's brand image. The company also hoped to increase communication between industry and academia. As a public benefit of the design competition, the company provided design students with a platform to demonstrate their creativity and help them to understand industry practice through these competition activities. At the same time, with the introduction of the company and competition, the Tt Company brand and product visibility was improved.

Additionally, from the design competition entries, the company discovered that some potentially creative external proposals could be developed through the internal R&D capability and transferred to innovative products. The competition began to be used as an innovation platform, and in eight years, the competition has been held in eight universities. The data collected are outlined below in Table 4.

Table 4 : Data Collection from the Tt Competition

Session		1st		2nd		3rd		4th	
Subject		Computer peripherals		Computer peripherals		Computer peripherals		Gaming mice	
Assessment Processing		Preliminary Assessment	Final Assessment	Preliminary Assessment	Final Assessment	Preliminary Assessment	Final Assessment	Preliminary Assessment	Final Assessment
Jury		Internal Professionals	External Experts	Internal Professionals	External Experts	Internal Professionals	External Experts	Internal Professionals	External Experts
Assessment Criteria	Design Concept	40%	40%	40%	40%	40%	40%	40%	40%
	Styling Design	40%	30%	40%	30%	40%	30%	40%	30%
	Feasibility	20%	30%	20%	30%	20%	30%	20%	30%
Outcomes		One design proposal has been commercialised		One design proposal has been commercialised		No design proposal has been applied		3 design proposals are under feasibility evaluation	
Session		5th		6th		7th		8th	
Subject		Gaming mice		Gaming gear、IOT and AI concepts		Gaming chassis		Gaming chassis	
Assessment Processing		Preliminary Assessment	Final Assessment	Preliminary Assessment	Final Assessment	Preliminary Assessment	Final Assessment	Preliminary Assessment	Final Assessment
Jury		Internal Professionals	External Experts	Internal Professionals	External Experts	Internal Professionals	External Experts	Internal Professionals	External Experts
Assessment Criteria	Design Concept	40%	35%	40%	35%	30%	30%	40%	40%
	Styling Design	40%	30%	40%	30%	40%	40%	40%	40%
	Feasibility	20%	35%	20%	35%	30%	30%	20%	20%
Outcomes		No design proposal has been applied		No design proposal has been applied		No design proposal has been applied		Design competition in progress	

Source: Thermaltake Technology.

3.2 The Theme of the Tt Competition

The theme of the Tt Competition has been adjusted annually. From the first year to the third year, the themes were defined as the best equipment for game players, and the design scope included computer chassis, power supply, CPU cooler, mobile device accessories, e-sports keyboard, gaming mice, and gaming headsets.

In the fourth and fifth years, for business strategies and requirements in the gaming market, the subject was defined as a single product category, a gaming mouse. In the sixth year, the subject was related to the application of innovative products and IOT (Internet of Things), which was expected to explore new inspirations for IOT concept application from the competition entries. With the 7th competition and the 8th in progress, the subjects are all set as gaming chassis design (computer case), which are decided by product market demand.

3.3 Tt Competition Assessment

The Tt Competition judging process includes two stages: preliminary assessment and final assessment. The jury set-up for the preliminary assessment comes from the company's internal professionals, including the design manager, senior product designers, product manager, and R&D engineers, who are committed according to their professional backgrounds and positions within the company.

From the 100 to 200 submissions received, 15 to 16 entries will be shortlisted for final judging. Every single shortlisted entry will be presented with prototypes or models for final assessment to decide if it will place in the competition. After the preliminary assessment, Tt Company arranges for all the shortlisted winners to visit its headquarters and participate in the technical seminars, in which Tt senior designers and engineers communicate with the participants and provide suggestions on improving their entries.

In the final assessment phase, the judging objects are the prototypes of the entries. The jury set-up for the final assessment combines internal and external experts, including the CEO, design manager, and senior designers of Tt Company, as well as design professors from the Industrial Design Departments of universities and external product designers. Before the final judging, the organiser explains the value setting of the competition and the judging criteria to the jury. The final judging is conducted through participants' presentations and work demonstrations. The final statistical average scores of the jury decide the winner list.

The assessment criteria are adjusted according to the organiser's expectations regarding the competition result. From the 4th competition to the present 8th competition, with the percentage of items set in assessment criteria, the concept design and the styling design show an upward trend, while the feasibility is down from 35% to 20%. Figure 2 shows the trend of assessment criteria in Tt design competitions.

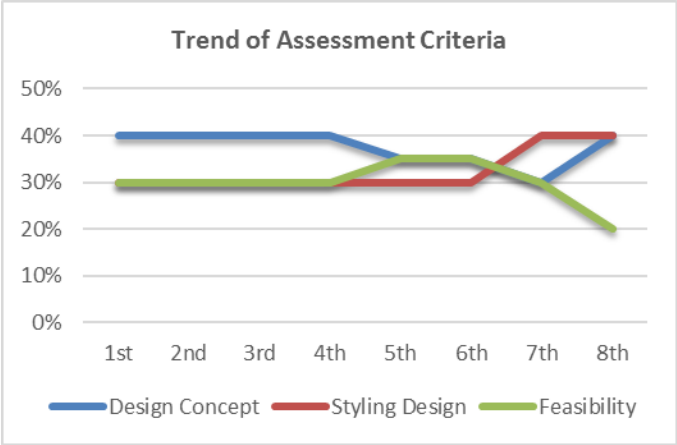

Figure 2: Trend of Assessment Criteria. Source: Thermaltake Technology.

3.4 The Winners of the Competition

Since the first Tt Competition, the company has launched two products which were developed from the concepts of the winners (Figure 3), and three entries are currently under market evaluation. If the entry is selected for commercialization, its entrant will be invited as an intern to participate in the whole process of the design development and the work commercialization. In order to respect the rights of authors, works selected to be commoditized will be awarded a prize.

Aside from commercialisation, the winning concepts and ideas can be transferred into innovation value in other ways. For example, the company established the IOT (Internet of Things) R&D Department in 2015, inspired by the winner's idea from the third competition, and it also motivated the sixth Tt Competition subject, which was the application of innovative products and IOT.

Figure 3: Satellite Portable Laptop Cooler. Source: Thermaltake Technology.

4 Interview Data Analysis

The purpose of the expert interviews was to understand the execution goals, execution methods, and implementation effectiveness of the design competition and to obtain expert advice on the design competition. Through the analysis on the interview content, the motivations to hold the Tt Competition are revealed, and the organisers' expectations and evaluation of the competition results are clearer and summarized.

4.1 The Competition Objectives

Through the analysis of the interview content, the initial motivation to hold the Tt Competition is to provide an innovative design platform to allow design students to participate in design practices, increase their understanding of industries, and to accumulate design experience with target-setting missions. In the meantime, the competition promotes the enterprise's

innovation value and enhances brand image through competition publicity, activities, and contestant participation.

Another public benefit of the design competition for design students is that the contestants themselves are the users of computer peripheral products and have rich user experience as e-sport players. They can use their creativity and enthusiasm and combine their own user experience in the design competition to create new product concepts or product improvement proposals, which will cultivate and nurture the product innovations in the company.

4.2 Setting the Competition Theme

In regard to the theme of the competition, the expert interview data suggest that, according to the sponsors, it should be the product category in which the company is leading and the themes should meet market demands. The experts believe that, with narrowly focused themes, the quality of design proposals submitted by the contestants is more in line with expectations. Innovation agenda in this case, participants have a defined theme direction, and their design concepts are led in deep in the designated field. Usually, it can propose new creative proposals for products, and new applications of technologies. With narrowly-focused subjects, it is easy to compare and assess the entries' innovativeness, and jury members' perspectives are more uniform. From a marketing perspective, the data suggest that by defining the framework of technical requirements and specifications of the themes, the winning concepts are more likely to be commercialised.

On the other hand, when innovation agendas have broader goals, although the proposals are diverse, due to the participants' limited understanding of products and industries, the entries lack design rationality.

From this case, it was found that with a broader theme setting, the design proposal suitable for commercialization. However, without a market and user demand survey, the actual market sales performance will not be as expected. However, a broader theme setting is to help explore new directions that differ from the existing market, and to perceive opportunities to develop a new product market.

4.3 The Competition Assessment

From the internal product development perspective, the design proposals in conformity with the themes and with a higher degree of completeness will be selected in the preliminary assessment stage, and in the final assessment stage, the ratio of rationality and technical feasibility will increase in the assessment on the design proposals.

As the creative design centre manager explained, since the 8th competition, the percentage of the concept design has increased but the feasibility has decreased, because the commercialization investment in the competition works may not be in line with the return of mass production. Therefore, if there is no definite marked demand, it is difficult to commercialize the product. If competitions focus on the innovative design concept of products, there is an opportunity to explore the possibility of application of new technology or the development of the emerging product market.

The preliminary assessment stage aims to select the design proposals not only with an innovative concept, but also considering user needs, marketability, and concept feasibility. Therefore, the jury in this stage needs a professional industry background. External experts

are invited as jury members in the final assessment stage in order to provide different perspectives to assess the entries, and to gain more design suggestions from outside.

4.4 Design Competition Achievements

The product manager said that, although there are many innovative entries in the competitions, they lack alignment with the consumer market. Most of them are just new concepts or ideas.

From the sponsor's perspective, if the winner's design is selected for feasibility evaluation, the market needs must be considered. The marketing evaluation, technology confirmation, and cost analysis all need to be carried out before the decision on the proposal's commercialisation.

From the product development perspective, the investment in mass production, such as tooling cost, is an important condition for concept commercialisation. The Tt Company CEO suggested that participants should make a preliminary analysis of their entries' market and user behaviours, and the entries submitted should comply with the company's existing product lines that have a precise marketing positioning in order to lower market risk (Lin, 2018). The marketing manager described the phenomenon of the commercialised winners gaining attention in the market due to the winners' creative concepts, but without good sales return because the products cannot meet the functional requirements.

5 Discussion

5.1 Competition Subject Setting and Its Effect

In the first three sessions of the Tt Competition, the themes were broader for the original goal setting of the competition, which were public benefit and brand image promotion. Two winning designs were selected to be commercialised and developed into new products to be launched on the market, resulting in attention in the market, but not a good sales return. The Gold Award in the third competition was a concept in IOT (Internet of Things), which motivated Tt Company to establish a new department in 2015, the IOT R&D Department, focusing on new IOT product research and development. Although the winning innovators under the broader themes could not be successfully developed into new products, they may be applied to a new product line or market. This is in line with the theory demonstrated by Lampel, Jha, and Bhalla (2012), that is, broader innovation agendas can reshape the market. According to the experience from Tt competitions, it seems that a broader design theme can explore new product design concepts.

While the competition was developing, it was also developed as an open innovation design resource. This change has shaped the competition subjects from a broader new concept design to narrowly-focused product design based on the company's innovative development strategies. With the subjects becoming more narrowly focused since the fourth competition, the participants are poised for in-depth exploration of user experience and behaviours. For example, there were three new concepts from the users' point of view in the fourth competition, and one of them was a woman's perspective, which enlightened the company to evaluate the market demands for this customer group. Such creativity is more likely to be feasible based on the company's existing product lines and is more likely to accelerate the company's new product and technology development. The analysis of the design subjects is outlined in Table 5 below.

Table 5 : The analysis of design subjects from the Tt Competition.

Type of subject	Process	Consequence
Narrowly-focused subject	In line with the company's innovation objectives	New design proposal
	In deep of the design concept	Accelerate technology
Broader subject	Diverse proposals	New design proposal
	Explore different market	Potential market direction

5.2 Competition Governance and Its Effects

The Tt Competition is a two-staged, multiple phase design competition, and the jury set up in these two stages is different. The preliminary assessment jury is comprised of internal experts from different departments, which filter the proposals using their professional background in products and industries, but from different perspectives. This stage increases the feasibility of the winning entries as creative design concepts.

In the final assessment stage, the jury includes external experts, such as professors from universities, senior designers, or research institutions. These members not only provide diverse external views on creative design, but also make sure the final winners will not be determined only by the company's new product development values.

According to the perspectives of the open innovation paradigm for managing industrial R&D, (Chesbrough, 2003) as ideas come from inside and outside, the project's value should not be bound inside either. The same is true in the design competition. It should have mixed-good internal and external benefits. If the beneficiaries only include internal members of the company, the unbalanced sharing of resources in competitions will lead to negative external perceptions. Other than copyright ownership and royalties, the chance for the entry itself to be developed is also very important. With mixed-good benefits, the promotion of innovation can be sustained, and it can increase the willingness of external resources to participate.

Differing from a general design competition, the Tt Competition provides technical seminars after preliminary assessment for top participants to get technical support and suggestions on the entries' feasibility and improvement from the company's designers and engineers. Also, the jury provides feedback on the participants' proposals in the final assessment. As a collaboration-orientated competition, the participants benefit from "education" and professional development. On the other hand, these technical seminars have another important meaning. Normally the design proposal development phase starts after the winners are revealed, but for the Tt Competition case, the development phase begins from the technical seminars, which is also beneficial to the company in terms of design proposal feasibility.

6 Conclusion

In summary, the design competition is an effective innovation method for companies if certain guidelines and subjects are met. Below are the highlights of the findings from this case study.

1. The subject of design competitions needs to be set according to the competition objectives of the organizer. The theme setting can be described as two types, a theme that is narrowly focused on a single product category, or a broader theme encompassing a range of product categories. The narrowly focused theme addresses new design proposals, solutions and new technologies that companies need. Under the broader subjects, besides the opportunity to find new design proposals, many of the divergent innovative ideas can provide a different or untapped product market direction from the existing products.

2. Two assessment stages and the jury set-up with internal and external experts ensure that the innovation resources scanned conform to the company's strategies and that the winners will not simply be determined by the company's values.

3. Technical seminars after the first stage provide participants with technical support, which reflects a collaboration orientation and mixed-goods benefits for public and private entities. Through the design competition, Tt Company benefits from increased brand awareness and external design resources, while the design students benefit from design practice and "education".

In line with a company's strategies and with complete planning and execution, serialized design competitions can be an effective innovation method for enterprises to search for new market directions, new concepts and solutions. In general, the Tt Creative Design Competition is a good example of open innovation reflecting its principle of integrating internal and external resources and mutual benefits, ensuring that the competition is ongoing.

From this study, it was also found that there are many points worthy of in-depth analysis in design competitions used as an innovation method. As Don Norman says, "We should have contests, but we should do them properly" (Norman, 2010).

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Effects of Strategic Orientation on Product Design: Focusing on the Relationship with the Product Life Cycle

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The purpose of this study is to clarify how a strategic orientation in product development organizations affects product design. While existing studies have shown that a company's strategic intent affects product design development process and corporate performance, these studies have not sufficiently clarify strategy-specific impacts on product design outputs. This study clearly identified the effects of four main types of the strategic orientation—"customer orientation," "competitor orientation," technology orientation," and "entrepreneurial orientation"—on product design outputs. This study also showed effects of each strategic orientation on product design outputs related to the product life cycle. This study demonstrated that the types of strategic orientation that could be effective on product design outputs differs in the growth and maturity stages of the product life cycle.

Keywords: Design Management, Strategic Orientation, Product Life Cycle

1 Introduction

This study clarifies how a strategic orientation toward product development affects product design. Existing studies on design management relate a company's strategic intent to product design process and corporate performance but never specify effects of the strategies (Swink, 2000; Sung & Gilmour, 2002; Ravasi & Lojacono, 2005; Marsili & Salter, 2006; Hsu, 2013). We show how four main types of the strategic orientation -"customer orientation," "competitor orientation," technology orientation," and "entrepreneurial orientation"- impact product design outputs with a focus on the relationship with the product life cycle. This is because the effects of strategic orientation are impacted by the market situation faced by a company (Jaworski & Kohli, 1993; Gatignon & Xeureb, 1997). This study gives further clarification on the effect of company's strategic behaviors on product design by analyzing how each of those four types affects product design outputs during the growth and maturity stages of the product life cycle.

2 Literature Review and an Analytical Framework

2.1 Design Management Goals and Performance

Product design is an important element, affecting the user's purchase preference, product sales, and corporate performance (Hertenstein et al., 2005; Guo, 2010). Design

management generally seeks to achieve differentiation from the competitors' products (Kotler and Rath,1984) by increasing innovativeness and uniqueness in its design (Truong et al., 2014). In fact, highly innovative and unique designs increase the appeal to users and performance of a product (Talke et al., 2009; Rubera, 2015). Therefore, we focus on the two qualities of design outputs- innovativeness and uniqueness- and examine to see if a product with these qualities achieves high performance.

2.2 Strategic Orientation and Product Design

Existing studies in design management generally relate a company's strategic intent to its development of product designs and corporate performance, but they seldom disclose the effects of specific strategies (Swink, 2000; Sung & Gilmour, 2002; Ravasi & Lojacono, 2005; Marsili & Salter, 2006; Hsu, 2013). Therefore, this study focuses on the concept of "strategic orientation" which dictates a company's strategic behavioral tendency. This strategic orientation has been thought to affect decisions in new product development, innovation creation, and a company's performance in various ways. Considering the fact that product design refers to product concepts, specifications, functions, and quality, as well as a company's philosophy (Borja de Mozota, 2003; Utterback et al., 2006), it is reasonable to say that product design largely reflect the company's strategic orientation. The main types of the strategic orientation are "customer orientation," "competitor orientation," "technology orientation," and "entrepreneurial orientation."

Customer orientation emphasizes responsiveness to customers by analyzing and understanding their needs. It raises corporate performance by increasing organizational learning and employees' organizational commitment (Narver & Slater, 1990; Kohli & Jaworski, 1990; Deshpande, Farley & Webster, 1993; Hult, Ketchen & Slater, 2005; Kirca, Jayachandran & Bearden, 2005). *Competitor orientation* emphasizes responsiveness to competitors' actions. It raises a company's commercial performance by creating superior products in competitive markets (Cooper, 1984; Narver & Slater, 1990). *Technology orientation* emphasizes aggressive acquisition of sophisticated technologies for new product development (Cooper, 1984; Kanter, 1988; Zhou, Yim & Tse, 2005). A company with high technology orientation chooses to establish new technological solutions to meet customers' needs and proactively aims for innovation creation through new technology development (Workman, 1993). *Entrepreneurial orientation* affects a company's performance by developing strategies through proactive policies, competitive aggression, and risk-taking approaches (Lumpkin & Dess, 1996; Lumpkin & Dess, 2001; Matsuo, Mentzer & Özsomer, 2002; Dess & Lumpkin, 2005).

2.3 Strategic Orientation and Product Life Cycle

As stated above, strategic orientation relates to decisions in new product development, innovation creation, and a company's performance and also has significant impact on product design outputs. However, whether a strategic orientation influences the performance depends upon the growth, uncertainty, and the degree of competition in the market (Jaworski & Kohli, 1993; Gatignon & Xeureb, 1997). In the analysis of the relationship between the product life cycle and customer orientation, Wong and Ellis (2007) find that the degrees and effects of customer orientation differ with stages of the product life cycle. Lumpkin and Dess (2005) also argue that the effect of an entrepreneurial orientation differs during the growth and maturity stages of a product life cycle.

2.4 Analytical Framework

Based on existing research, we have set up an analytical framework with the focus on a company's strategic orientation, market situation in the product life cycle, and product design outputs. First, existing studies show that a strategic orientation impacts product design output. We analyze how a strategic orientation toward customers, competitors, technology and entrepreneurship relates to product design outputs. Existing studies also show that the degree to which strategic orientation affects product design outputs differs with the product life cycle. We focus on the growth and maturity stages of the product life cycle as factors that interact with strategic orientation to influence product design outputs because the growth stage, where the market expands, and the maturity stage, where the competition intensifies, are very important stages that largely affect a company's market shares and performance.

We use the analysis of interactions for these environmental factors. This analysis of interactions considers the effect of the change in the concerned variables under a certain condition of effect. This, therefore, enables us to analyze the effect of strategic orientation on product design outputs in consideration of the factors of the product life cycle.

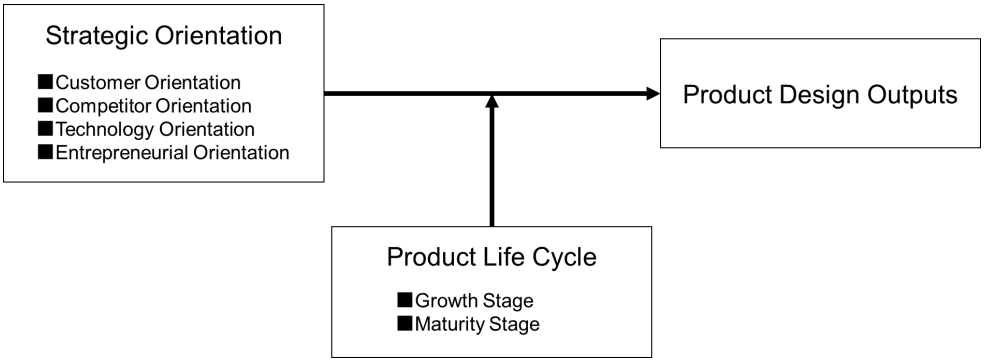

Figure 1. Analytical Framework

3 Survey Overview and Measurement

3.1 Survey Overview

In this study, we carried out a questionnaire survey, "Survey on Corporate Product Development Activity," targeting manufacturing companies listed in the first section of the Tokyo Stock Exchange (TSE). Between November and December 2017, we surveyed 5,523 employees of 511 manufacturers via the Internet, for which we received responses from 2,226 employees from 391 companies. The questionnaires were given to employees in the product development field with questions related to their companies' product development. We chose the former group of respondents because their established companies have long-standing product development organizations. This group also encompasses companies that produce a diverse array of products in differing markets, including clothing and textiles, chemicals (cosmetics), household goods, electric equipment (appliances, machine equipment, and computers), and automotive and transport equipment.

3.2 Measurement Scale

Generally, design management seeks to create design output with high innovativeness and uniqueness to differentiate products from competitors (Kotler & Rath, 1984; Talke et al.,

2009; Truong et al., 2014; Rubera, 2015). Those design outputs are then expected to contribute to a company's performance (Hertenstein et al., 2005; Guo, 2010). Subjects entered responses on a 7-point Likert scale to the questions related to "their organizations' product designing" such as "Does your company often come up with new designs?," "Can your company's products be quickly differentiated by consumers from other companies'?," and "Has your company been successful in developing new products that can capture major market shares?" Verification factor analysis (VFA) measured principal components.

We set the four previously indicated orientations (customer, competitor, technology, and entrepreneurship) as elements in a strategic orientation toward product development. We then drew questions from existing research, responses entered by subjects on a 7-point Likert scale, and VFA measured results.

Finally, we examined the former half (growth stage) and the latter half (maturity stage) of product lifecycles. The growth stage is the stage when products start to be broadly accepted in the market, but new competitors also enter the market, and functionally enhanced products are launched by other companies. Product design and technology are fluid during this stage, making the market and the technology highly uncertain (Levitt, 1965; Rink & Swan, 1979; Moon, 2005). The maturity stage exhibits a gradual transition to process innovation and incremental innovation with the emergence of a dominant design (Abernathy and Utterback, 1978). Therefore, the competition intensifies, as does the need to improve existing product functions and technologies and sales strategies (Levitt, 1965; Rink & Swan, 1979; Moon, 2005). Subjects answered questions about both stages on a 7-point Likert scale, and VFA analysed components.

Table 1 Factor Analysis

Factors	Items	Factor Loadings	Cronbach's α	Contribution Ratio (%)	Existing Research
Customer Orientation	The satisfaction of existing customers is an important business goal.	.807	.715	63.841	Narver & Slater (1990)
	Actions that meet customer needs are emphasized.	.825			
	We have almost no biases when interpreting customer information.	.764			
Competitor Orientation	We target markets where we have an advantage over competitors.	.790	.740	65.801	Narver & Slater (1990)
	We always respond to competitive actions by competitors that threaten our company.	.818			
	Our business structure and systems are coordinated in response to target markets.	.826			
Technology Orientation	New product development tends to use sophisticated technologies.	.907	.783	82.189	Zhou, Yim & Tse (2005)
	Our new products always use cutting edge technology.	.907			
Entrepreneurial Orientation	We tend to agree with high-risk projects (that have the likelihood of creating very high profits).	.807	.724	63.558	Lumpkin & Dess (1996)
	I believe that achieving company goals requires bold actions in response to changes in environment.	.743			
	We are bold and aggressive in making the most of potential opportunities.	.854			
Growth Stage	Our companies accept new product ideas well.	.756	.706	54.680	Zhou, Yim & Tse (2005), Wong & Ellis (2007)
	New competitors are entering the market.	.612			
	The company's foundational technologies are rapidly changing.	.777			
	We are realizing many new product ideas through technology innovation.	.797			
Maturity Stage	Customer needs in response to our products are changing over time.	.669	.652	49.524	
	Competitors are frequently revising the functionality of their products.	.805			
	Competitors are frequently revising their sales strategies.	.789			
	Current technology is often improved in new product development.	.514			
Product Design Outputs	The product designs provided by our company often include new things.	.851	.731	65.180	Talke et al.(2009), Truong et al.(2014), Rubera(2015), Guo (2010)
	Consumers immediately differentiate our company's product designs from those of our competitors.	.811			
	We are successful in developing hit products that capture major market shares.	.757			

Notes: N=2,226

Table 2 Descriptive Statistics Value and Pearson's Correlation Coefficients

Items	Average	S.D	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Customer Orientation	0.000	1.000	1.000												
2. Competitor Orientation	0.000	1.000	.779 **	1.000											
3. Technology Orientation	0.000	1.000	.623 **	.662 **	1.000										
4. Entreprenurial Orientation	0.000	1.000	.603 **	.653 **	.676 **	1.000									
5. Customer Orientation × Growth Stage	0.483	1.149	-.149 **	-.093 **	-.066 **	-.037	1.000								
6. Competitor Orientation × Growth Stage	0.523	1.180	-.090 **	-.122 **	-.093 **	-.044 *	.799 **	1.000							
7. Technology Orientation × Growth Stage	0.596	1.175	-.064 **	-.093 **	-.157 **	-.072 **	.684 **	.726 **	1.000						
8. Entrepreneurial Orientation × Growth Stage	0.533	1.134	-.038	-.045 *	-.075 **	-.044 *	.680 **	.720 **	.745 **	1.000					
9. Customer Orientation × Maturity Stage	0.299	1.174	-.004	.042 *	.027	.058 **	.553 **	.441 **	.401 **	.403 **	1.000				
10. Competitor Orientation × Maturity Stage	0.319	1.232	.040	.047 *	.038	.067 **	.433 **	.556 **	.422 **	.426 **	.777 **	1.000			
11. Technology Orientation × Maturity Stage	0.318	1.197	.026	.039	.008	.039	.420 **	.450 **	.570 **	.452 **	.678 **	.746 **	1.000		
12. Entrepreneurial orientation × maturity Stage	0.327	1.168	.059 **	.071 **	.040	.078 **	.401 **	.431 **	.428 **	.589 **	.704 **	.744 **	.733 **	1.000	
13. Product Design Outputs	0.000	1.000	.473 **	.506 **	.533 **	.494 **	-.024	-.072 **	-.051 *	-.026	.054 *	.055 **	.035	.059 **	1.000

Notes: N=2,226 **<.01, *<.05

4 Analysis Results and Discussion

Table 3 Multi-Regression Analysis Result

Items	β	t-value	Significance
Intercept	-.011	-.541	
Customer Orientation	.108	3.705	***
Competitor Orientation	.134	4.382	***
Technology Orientation	.269	10.237	***
Entreprenurial Orientation	.158	6.210	***
Customer Orientation × Growth	.096	3.009	***
Competitor Orientation × Growth	-.146	-4.461	***
Technology Orientation × Growth	.055	1.924	*
Entrepreneurial Orientation × Growth	.002	.077	
Customer Orientation × Maturity	-.019	-.652	
Competitor Orientation × Maturity	.077	2.477	**
Technology Orientation × Maturity	-.034	-1.223	
Entrepreneurial Orientation × Maturity	-.004	-.126	
adjusted R square		.346	
F		98.892	

Notes: N=2,226, ***<.01, **<.05, *<.1

First, each of the four strategic orientations have positive effects on product design outputs. It is especially noteworthy that customer orientation has a positive effect on with product design outputs.

Existing studies note that customer orientation boosts corporate performance by increasing organizational learning and employees' organizational commitment (Narver & Slater, 1990; Kohli & Jaworski, 1990; Hult, Ketchen & Slater, 2005; Kirca, Jayachandran & Bearden, 2000). However, although a customer orientation contributes to incremental innovation, it can hinder radical innovation (Koldor, 1971; Bennet & Cooper, 1981; Utterback, 1996) because customers do not fully know their potential needs and lack a sense of ideal product design or functionality (Utterback, 1996). Nevertheless, customer orientation has a positive effect on performance in this study where product design is a performance variable. These results indicate that in the field of product designing, product development activities that emphasize on responses to the needs and knowledge of users effectively generate highly innovative and unique designs that can be differentiated from those of competitors and had never existed in the market.

Second, our results show that effects of strategic orientation toward product development differ during the different stages of the product life cycle. During the growth stage customer and technology orientations have a positive effect, whereas a competitor orientation has a negative effect. However, during the maturity stage, competitor orientation has a positive effect.

Generally, the growth stage features relatively high market and technological uncertainty as there is fluidity in product designs and technologies with incompletely defined customer needs (Levitt, 1965; Rink & Swan, 1979; Moon, 2005). Customer orientation has a positive impact on product design

during the growth stage because to lead the market, companies respond to “early adopters”, who seek more innovation and originality in product designs. In other words, in the growth stage, companies focus on searching for potential customer needs and increase innovativeness and uniqueness of their product designs by reflecting those needs. Existing studies on relations between customer orientation and innovation, however, mainly focused on responses to visible needs of “late majorities” who bought after a product’s functionality and design were relatively set in the market (Rogers, 1995), making customer orientation seem as the setback for radical innovations. Our results indicate that customer orientation during the maturity stage does not affect product design outputs. They endorse existing research. These results also indicate that product design outputs change depending on what type of customer needs a company focuses to respond to at each stage of the product life cycle.

Our results show that technology orientation also increases product outputs during the growth stage, which has no dominant design, and the product technology is highly fluid. Eisenman (2013) notes that innovative technology development increases innovativeness of design outputs because a product’s concept and value are more easily conveyed to customers by embedding innovative technologies in the product design. In short, in the growth stage with a relatively high uncertainty of technology, innovative technology development impacts product designs.

Finally, competitor orientation correlates negatively with the impact of product design during the growth stage but positively during the maturity stage. This finding suggests that during the maturity stage, when customer needs are more fixed and stable, there is benefit from focusing on differentiating products and emulating market leaders. Emphasizing on responding to competitors during the growth stage has the opposite effect because uncertainty in the market itself is high.

5 Contribution and Limitations of the Study

First, it empirically and quantitatively verified how four elements of strategic orientation separately influenced product design outputs. Existing studies on design management address how overall corporate strategy for design affects development process of product designs and corporate performance (Swink, 2000; Sung & Gilmour, 2002; Ravasi & Lojacono, 2005; Marsili & Salter, 2006; Hsu, 2013) but do not clarify strategy-specific impacts, whereas this study clearly identified the effects of the four main strategic orientations (customer orientation, competitor orientation, technology orientation, and entrepreneurial orientation) on product design outputs.

Second, related to the product life cycle, we showed relative effects of each strategic orientation on product designs. Existing studies clarified the effect of customer and entrepreneurial orientations in relation to the product life cycle but only examined them individually, whereas this study examined each component of the strategic orientation at the same time and demonstrated that the type of strategic orientation that could be effective on product design outputs differs in the growth and maturity stages of the product life cycle.

Third, our results suggested that the effect of customer orientation possibly differs depending on the types of customers that a company focuses on in its product development. Existing studies show that customer orientation has no effect on radical innovation. However, our results showed that, in the growth period with the focus on potential needs of customers, innovativeness and uniqueness of product designs increase because of those progressive customer needs being reflected in product design development.

However, this study also has its limitations. For example, we sampled 2,226 employees of 391 manufacturers listed in the first section of the TSE without considering differences in product areas. Because the length of product life cycles and competitive circumstances differ by industry, future studies should measure the effect of strategy orientation with these differences in mind. Additionally, we measured the strategic orientations of product development organizations through individual employee’s responses in each company. Because the strategic orientation is a concept indicating strategic behavioral tendency of a company as a whole, future efforts should be made to measure the tendency on an organizational level.

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How to design for Death

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Designers are increasingly investigating a taboo topic, design for death. Specifically, we examined whether embedding the opposites to death could create aesthetic appreciation and acceptance. Russell and Barrett's (1999) emotional model and seven design techniques derived from the protection frame were our theoretical base. Utilizing sixty-six representative works from the "Design for Death" competition in 2013, sixty-one participants judged whether they would adopt the present designs for themselves, for the loved, and for the public. The results demonstrated that two design schemes, "born (newborn-dead)" and "endless (eternal-fading away)," successfully created aesthetic appreciation and acceptance. By these efforts, we indicate the way to turn death generated emotions (i.e., poignancy, anxiety, disgust, and indignation) into aesthetic appreciation and acceptance. Furthermore, a significant gap between adopting the designs for themselves and their loves and adopting the designs for the public was found, which starts a discussion about functionality and social welfare with design for death.

Keywords: semantic contrast; semantic design; death attitude

1 Introduction

How to design for death? In this study, we outline an approach that is different in purpose and even opposite consideration in designing products that stimulate positive aesthetic emotions. It is different in purpose because we aim to discuss a taboo topic, design for death. Despite its difficulty, a good design for death, or any design roots in negative emotions, creates a richer than usual experience (Fokkinga & Desmet, 2013). To show how to design for death, it is necessary to know negative emotions and rich experiences at first.

According to Hung, Chen, Lin, and Yang (2017), designs involving negative semantics as fear, anger, disgust, and sadness (Russell & Barrett, 1999) significantly surprised users and attracted ones' curiosity. However, the most impressive finding was the contrast of sadness (negative emotion), and epiphany (positive emotion) in a design created a sense of poignancy that directed to a superior aesthetic appreciation to the other three negative emotions. Poignancy is the feeling overwhelmed with sadness over something (Fokkinga & Desmet, 2013). For example, Zhuangzi's (an ancient Chinese philosopher) singing for his wife's death seems strange at first consideration: why should there be any sadness involved in such a delight experience? We argue that people feel overwhelmed by witnessing a certain irrecoverable negative, a relative's death for an instance, which momentarily

activates their cynical beliefs. Such overwhelming feeling is accompanied by a sense of helplessness, as sorrow noted by Ekman (2007), which triggers passive action tendency. However, when something beyond that overwhelming feeling, agony occurs (Ekman, 2007). Instead of passively sorrowing at the negative, people spirit up to fight with that negative, which brings us the epiphany sometimes. That epiphany riches ones' experience and then moves us. Back to Zhuangzi's signing, according to Zhuangzi's words, he had suffered the pain of wife's death; however, when he realized the life as an endless cycle of birth, living, death, and reincarnate, he got the epiphany over the death.

Epiphany depends on an extreme understanding and wisdom after all. That is why people seldom get joyous experience from a relative's death. As a designer, we investigate how to create such epiphany to turn the poignancy into a joyous experience. In this study, seven techniques were developed that offer prefabricated design map, which is intended to lower the threshold to design for death.

2 Adapting the protective frames for death designs

For any design involving a negative emotion, designers should create a protective frame to reverse the negative emotion so that it can be enjoyable for the user. We start our discussion at Fokkinga and Desmet's (2013) four types of protective frame: the detachment frame, the safety-zone frame, the control frame, and the perspective frame. The detachment frame is constructed by altering the negative stimulus in such a way that users are merely confronted with a presentation of it (such as abstraction or simplification). The safety-zone frame physically distances users from the negative stimulus so that they are in the psychological safe zone. The control frame increases the amount of control for a user to overcome the interaction with the negative stimulus. Finally, the perspective frame provides a perspective on the wider implications of the negative stimulus or the reaction toward it.

This study utilized 159 designs and generalized seven techniques by five design graduate students based on abovementioned four protective frames (see Table 1). We further argue that the contrasts of styles or meanings create highly aesthetic preference (Hung & Chen, 2013, 2015). Therefore, the hypotheses are bound to the opposite of death, birth, to create epiphany under the protection of detachment, safety-zone, control, and perspective frames.

Table 1 Seven techniques for death design.

Design techniques	Reference frame	Cases
1. Simplified abstraction	Refer to the "detachment frame" for simplifying the product appearance.	A 3D printed pyramid-like urn for ashes
2. Proximity	Refer to the "safety-zone frame" for encouraging the user to approach.	An urn is covered by a cute fluffy toy
3. Functionality	Refer to the "control frame" for adding practical functions.	Environmental considerations; engraving a QR code on the tombstone to recall the past
4.Emotional resonance	Refer to the "control frame" for stimulating emotional linkages and meditations.	A design of combinable family urn for commemorating
5. Eternity perspective	Refer to the "hope frame" for representing an eternal feeling.	Making ashes (after cremation) into diamonds or glass balls
6. Relief perspective	Refer to the "hope frame" for representing a relief feeling.	Fixing the urn on a balloon and sprinkling the ashes into the sea
7. Rebirth perspective	Refer to the "hope frame" for representing a rebirth feeling.	To grow plants from the urn containing the ashes

2.1 Measuring for the preference

We measured the attitude of adoption preference as dependent variable from three perspectives: “I will adopt this design for myself,” “I will adopt this design for my loves,” and “the society should adopt this design.” These perspectives referred to the scale of Collett-Lester Fear of Death (CLFDS) which not only measures people’s attitude to their death and dying, but also measures the attitude to other people’s (intimate or stranger) death and dying. Former comparison study also showed that the CLFDS appeared to have good validity and reliability (Dadfar & Lester, 2016). Furthermore, we measured the “sense of fear” to confirm the influences of design techniques on transforming the “dead” feeling in design works.

3 Research procedure

3.1 Stimuli

One hundred and fifty-nine works from the campaign “Design for Death” (https://www.designboom.com/competition/design-for-death/) held by Designboom in 2013 were collected to be our stimuli. We believe that these 159 diversified works with different product types are the excellent stimuli because they stood out from the perspective of 2,050 designers over 96 countries which could enhance the generalization of our findings in different domains.

These design works were printed in 10-by-10-centimeter cards and noted its product types and main function of it. One hundred and ten works selected via the aid of three postgraduates by removing works that were not easy to understand only by a picture (especially for the space design, webpage or media design). Then, five design experts sorted the works depended on the similarity. After a hierarchical analysis and considering the representativeness in each cluster, sixty-six design works were settled as our stimuli.

3.2 Participants

Sixty-one undergraduates (37 females; age from 18 to 27) recruited in an industrial design school to participate in this study in change of $3. The investigator also confirmed with participants that they have never known these “design for death” campaign before.

3.3 Procedure

The experiment was conducted via a web-survey system. Participants reviewed and evaluated the design works in random order through the computers in the identical model in the university to prevent possible confounding effects from the devices, for example, screen size and display. In each review, participants evaluated the work by eleven items (including seven items for design techniques, three items for preference of adoption, and one item for indicating fear) on a 5-point scale (1 = extreme disagree to 5 = extreme agree). In average, participants completed the task in 45 minutes.

4 Results

4.1 Main techniques for death design

A factor analysis with Oblimin’s non-orthogonal rotation was conducted and found two critical factors: “born” (eigenvalue =3.29) and “endless” (eigenvalue =1.749), which accounted for 71.83% of the variances. Three criteria were observed in differentiating the design concepts, which are “proximity,” “functionality” and “rebirth perspective.” Furthermore, two concepts, “simplified abstraction” and “emotional resonance” grabbed the works together (see Table 2).

We also confirmed that the “born” factor have significantly linear correlations with “rebirth” ($r = 0.79$, $p < .05$) and “sense of fear” ($r = –0.66$, $p < .05$), while the “endless” factor had significantly linear correlations with “eternality” ($r = 0.93$, $p < .05$) and “relief” ($r = –0.81$, $p < .05$). To visualize our findings, we mapped the 66 design works into two paired sub-factors: “newborn-dead “and “eternal-fading away” in Figure 1.

Table 2 Factor analysis for seven death design techniques.

Content of items	Factor1 **Born** (newborn–dead)	Factor2 **Endless** (eternal–fading away)
Proximity	0.932	0.003
Simplified abstraction	0.711	0.279
Rebirth perspective	0.815	-0.115
Functionality	0.737	-0.283
Emotional resonance	0.548	0.463
Eternity perspective	0.177	0.884
Relief perspective	0.388	-0.904
Sum of squared loading (Eigenvalue)	3.286	1.743
Percentage of variance explained (%)	46.94	24.90
Cumulative percentage of variance (%)	46.94	71.83

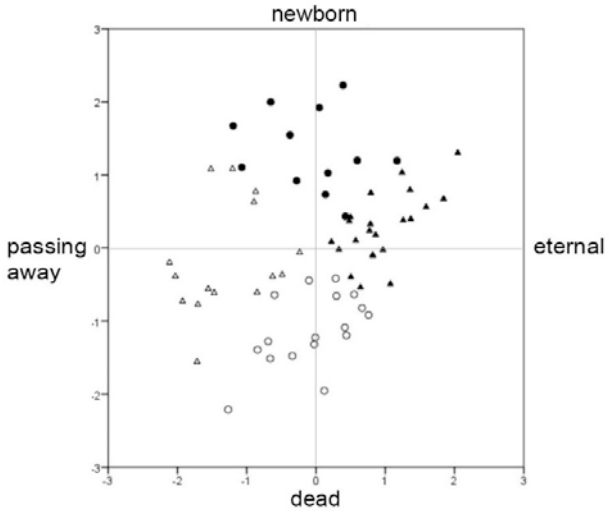


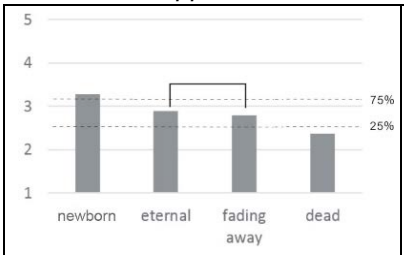
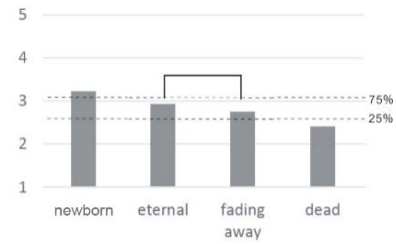
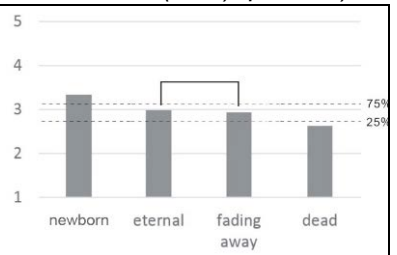
Figure 1. Main factors for death design (●: newborn (n=12) ; ○: dead (n=17) ; ▲ : eternity (n=22) ; △: fading away (n=15))

ANOVAs were conducted to examine whether comparing with merely expressing “death,” embedding “newborn,” “fading away,” and “eternity,” in the designs enhanced participants’ design adoptions for themselves, for their loves, and for the public as shown in Table 3. The results showed that adding “newborn,” “passing away,” and “eternity” to designs enhanced the participants’ adoptions from all the three perspectives. Among the three factors, embedding “newborn” in designs had most superior in adoptions for themselves, for their loves, and for the public. Following the “newborn,” “eternity” was superior to fading away in adopting for their loves. Furthermore, via the analysis on feeling of fear, comparing with mere “death” expression, we got that embedding “newborn” in the design was excellent at eliminating participants’ fear and following were the “eternity” and “relief.”

These findings confirmed our arguments that adding the opposites (namely, “newborn,” “eternity,” and “fading away” in this study) to “death” in design could achieve high aesthetic

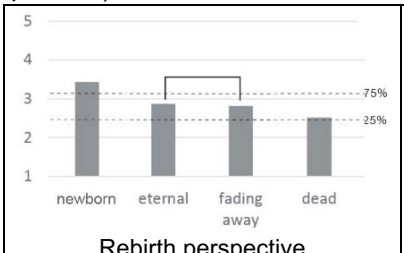
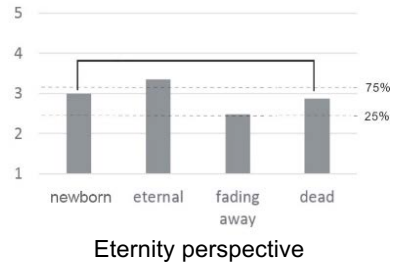
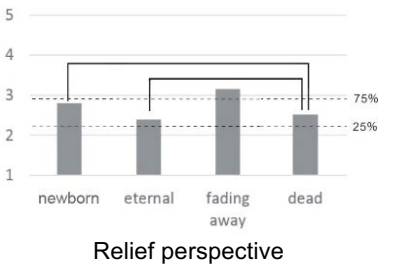
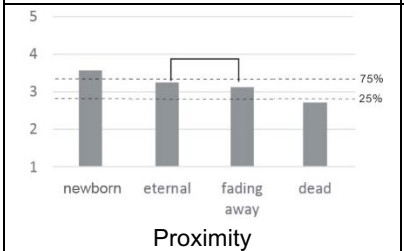
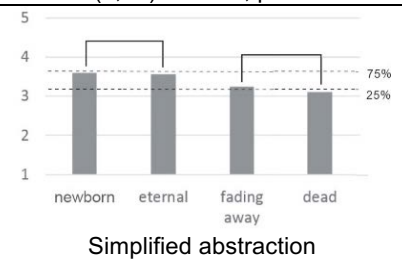
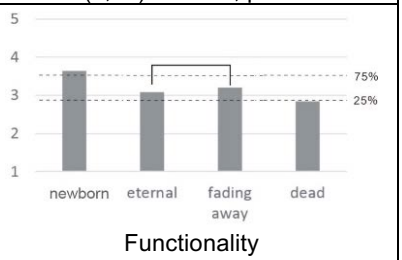
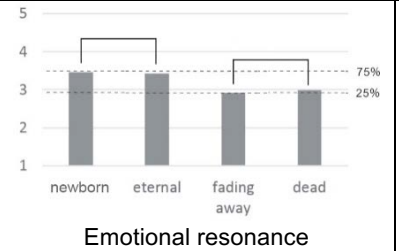
appreciation and acceptance. Among the three opposites which we proposed in the present study, “newborn-dead” was the most effective scheme in design for death.

Table 3 Comparing with merely expressing the sense of death, adding three opposites to the design for death on the three types of adoption (The lid-like connection denotes the non-significant difference between two opposites of death; the dotted line denote the first (25%) and the third (75%) quartiles).

 I will adopt this design for myself F (3,62) = 28.21; p < .05	 I will adopt this design for my loves F (3,62) = 26.92; p < .05	 The public will adopt this design F s(3,62) = 26.91; p < .05

Further examinations were conducted to reveal what design techniques involved underlying the abovementioned enhancement of aesthetic appreciation and adoption. Table 4 showed the results. “Newborn” not only conveyed the highest “rebirth” but also “proximity,” “functionality,” and “emotional resonance.” In addition, “newborn” also referred to “eternity” and “relief” although its impact was not competing with “proximity.” Drawing from these results, “newborn” (an opposite of death) gained the advantages from all the seven protective frames.

Table 4: Four sub-factors on the seven design techniques (The lid-like connections denote non-significant between two sub-factors; the dotted line denotes the fist (25%) and the third (75%) quartiles).

 Rebirth perspective F (3,65) = 21.66; p < .05	 Eternity perspective F (3,65) = 25.95; p < .05	 Relief perspective F (3,65) = 23.96; p < .05
 Proximity F (3,65) = 39.28; p < .05	 Simplified abstraction F (3,65) = 15.74; p < .05	 Functionality F (3,65) = 13.16; p < .05
 Emotional resonance F (3,65) = 17.89; p < .05		

4.2 Representative examples of four sub-factors

The work of “emergence,” as shown in Figure 1, is a biodegradable coffin which could enrich the soil and facilitated the plant growth. Most of the participants confirmed the plant growth representing the “newborn” (rebirth = 4.03, ranking =1) and somewhat “eternity” and “relieved” (eternity = 3.25, ranking =16; relief = 2.67, ranking = 26). These opposites of death eliminated the feeling of fear (proximity = 3.85, ranking = 1; fear = 1.95, ranking = 61). The consideration of biodegradability and enrichment of organic substances was beneficial and practical for environment (functionality = 3.89, ranking = 3). Participants also appreciated the simple design for the cemetery, tombstone, and coffin (simplified abstraction = 3.61, ranking = 18). A coincidental support came from its first prize in the Design for Death competition. Based on these evidences, we believe that “newborn” shine the most effective way to create aesthetic appreciation and adoptions in design for death.

Figure 1. The representative for embedding “newborn” in design for death (“Emergence” by Enzo Pascual, Pierre Rivière from France).

The work of “one wrapping of mortality,” as shown in Figure 2, presents the work while adding “eternity” to design for death. Participants rated this work with the highest “eternity” (eternity = 4.1; ranking = 1) but lower “relief” (relief = 2.30, ranking = 56). The design concept is to concentrate the remains of the deceased into a diamond, which also provides a way to deal with the dust from cremation and limit spaces of burial. Participants interpreted this work being eternal, love, small, clear, decorative, sparkling, and expensive. These associations may get participants being close to this ornament design (proximity = 3.75, ranking = 3; simplified abstraction = 3.79, ranking = 4; emotional resonance = 3.64, ranking = 6; fear = 1.82, ranking =65).

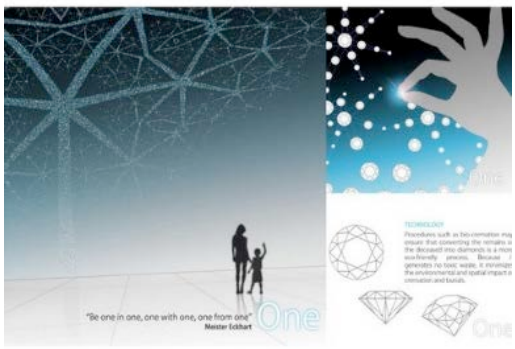


Figure 2. The representative for embedding “eternity” in design for death (“One wrapping of mortality” by Alessandro Falca, Magnus Winther from Sweden).

The work “urn for a memorial ceremony on water,” as shown in Figure 3, had the highest relief rating but relatively low eternality from our participants’ view (relief = 3.85, ranking=1; eternality = 2.49; ranking=54). The designer combined several types of clay and natural or recycled materials to make a bowl-like urn, which can slowly sink in minutes and totally dissolve within a few days. Participants rated this work to be simple and low sense of fear (simplified abstraction = 3.72, ranking=11; proximity = 3.56, ranking =12; fear = 2.13, ranking = 47). Beyond the relief feeling, “urn for a memorial ceremony on water” also implied somehow association with rebirth (emotional resonance = 3.43, ranking=21; rebirth = 2.89, ranking = 23; functionality = 3.3, ranking = 28).

Figure 3. The representative for embedding “relief” in design for death (“Urn for a memorial ceremony on water” by Agnes Hegedus from Hungary).

Finally, we presented an example which had relative low “reborn,” and “eternity” (rebirth = 2.53, ranking = 56; eternity = 2.43, ranking = 64). Without adding newborn and eternity to the design, participates felt fear (fear = 3.3, ranking =1) and kept far from it (proximity = 2.33, ranking = 66). The urn contains ash and blows the smoke ring slowly since it also functions as air-refresher or humidifier. In the creator’s words, he intended to remember the moment when his father blew the smoke ring to amuse him in his childhood. However, participants could not get his idea; and, the generated smoke made the dead even more tangible and scared our participants (emotional resonance = 2.77, ranking = 56; simplified abstraction = 3.28, ranking = 44; functionality = 2.89, ranking = 48), although the smoke blowing in the air somehow implied a sense of relief (relief = 2.74, ranking = 22).

Figure 4. The representative for expressing mere “death” in design for death (“Smoke ring” by Xueping Chen from China)

4.3 Adoption for oneself, for the loves, and for the publics

The next issue would be whether participants had different criteria for adopting the designs for themselves, for their loves, and for the public. The pair t-test showed that that participants

had higher threshold for adopting a design for themselves ($t = 7.93$, $p < .05$) and for their loves ($t = 8.24$, $p < .05$) than for the public. The thresholds were similar for adopting for themselves and for their loves ($t = .41$, ns.). There is a gap between adopting a design for oneself and the loves and adopting it for the public.

To concretize above relationships, correlations were conducted among the three types of adoptions by the seven design techniques. Table 3 demonstrated the correlation coefficients. The functionality was the most central for considering whether the design would be adopted by the public or not. Figure 5 provides an example (functionality = 4.03; ranking = 1), the work of "solar powered tomb stone," where a concave solar powered grave integrated with mirrors that could redirect sunlight to a central heating tower to generate electricity for public use. Such design for death would be highly adopted for the public but indefinitely be adopted for oneself and for the loves.

*Table 5 Pearson's correlation coefficients between three types of adoption on seven design techniques (Note: * p < .05).*

	Functionality	Emotional resonance	Eternity	Proximity	Simplified abstraction	Rebirth	Relief
for oneself	r = .63 *	r = .60 *	r = .32*	r = .95 *	r = .65 *	r = .65 *	r = .21
for loves	r = .58 *	r = .66 *	r = .36 *	r = .95 *	r = .65 *	r = .64 *	r = .15
for society	r = .76 *	r = .52 *	r = .26 *	r = .91 *	r = .59 *	r = .60 *	r = .21

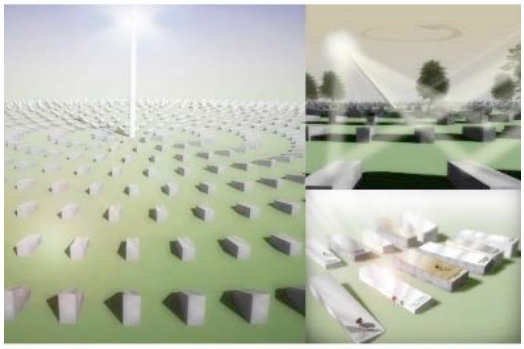


Figure 5. The design which had the highest rating of "functionality" ("Solar powered tomb stones" by Lecafelkf from China)

5 Conclusion

In this study, we have introduced seven techniques to design for death. It seems indeed possible to deliberately turn sadness (sorrow and agony) into attractive and appreciated designs. In particular, we found that contrast between born and dead play the best role in transforming fear and anxiety regarding death into user appreciation compared to the contrast of "eternal–fading away." These findings not only explain the main techniques used in death design but also extend the hypothesis–applying the opposites of death (i.e., reborn, eternity, and fading away) to the designs would create aesthetic appreciation and adoption. Furthermore, we noted that people had different criteria for adopting a design for oneself, for the loves, and for the public. There was a gap between in-group members (oneself and the loves) and out-group ones (the public). Therefore, designers should carefully consider the target users in design for death. As an initial examination, our participants were the undergraduates in a comprehensive university located in Asia area. Future studies could further consider the cultural differences, the disparity in age, or attitudes for death to generalize our findings.

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Investigating Product Competitiveness: the Comparative Study on Consumers' Evaluation of Design Award-Winning Products between Chinese Brands and International Leading Brands

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Design can contribute to product competitiveness, which further boosts firms' competitiveness. Design can improve the competitiveness of products in different ways, such as creating differentiating appearances to draw consumers' attention in cluttered markets, offering more usable and superior product features and more enjoyable product experience, and proposing a new meaning to a product. China is in the middle of the transition. Chinese firms endeavour to upgrade the value chain to improve the competitiveness of developed products. With evidence on the extensive efforts of Chinese firms paid on design, this study aims to investigate the competitiveness of products developed by Chinese firms. Specifically, based on the innovation pyramid framework (Rampino, 2011), this study examines consumers' evaluation of design award-winning products in terms of overall evaluation, aesthetic innovation, usage innovation, meaning innovation, and typological innovation. Moreover, as consumers' evaluation is influenced by contextual factors, such as country-of-origin effect and prior experience, we conducted comparative study through inviting consumers from China and Netherlands to evaluate products from Chinese firms and international leading brands. Results showed that Chinese consumers evaluate Chinese products more positively than international leading brands in terms of overall evaluation, usage innovation, meaning innovation, aesthetic innovation, and typological innovation. Differently, Dutch consumers evaluate international leading brands more positively than Chinese brands in terms of overall evaluation and meaning innovation. However, Dutch consumers do not show significant differences between Chinese brands and international leading brands regarding usage innovation, aesthetic innovation, and typological innovation. Theoretical and practice implications are discussed.

Keywords: Chinese design; innovation pyramid; product competitiveness; value of design

1 Introduction

Design can contribute to product competitiveness, which further boosts firms' competitiveness (D'Ippolito, 2014; Hertenstein, Platt, & Veryzer, 2005; Roy & Riedel, 1997). Design can improve competitiveness of products in different ways, such as through creating differentiating appearances to draw consumers' attention in cluttered markets (Berkowitz, 1987; Gemser & Leenders, 2001; Person, Schoormans, Snelders, & Karjalainen, 2008), offering more usable and superior product features, providing more enjoyable product experience (Hekkert & Leder, 2008; Jordan, 2002), and proposing a new meaning to a product (Verganti, 2009).

Considering the significant contributions of design to product competitiveness, Chinese companies have paid extensive attention on design. China has been long considered a manufacturing giant with a focus on original equipment manufacturing (OEM) business. Chinese firms had thus gained low-profit margin and lacked innovation capability to compete with international leading brands (Liu, Liu, & Zhang, 2018). However, the situation has been changing. Chinese firms endeavour to upgrade the value chain to improve the competitiveness of developed products (Liu, 2016b). The national government has also realized the urgency to improve product competitiveness and published the national policy for transforming from 'Made in China' into 'Created in China.' To achieve this transition, design has been highlighted as the key engine (Lu, 2013).

Against this background, Chinese companies have paid extensive efforts on design to improve product competitiveness. There is evidence showing that Chinese companies have started to integrate design in all the phases in new product development (NPD) process, in order to develop products with increased utility (Zhang, Hu & Kotabe, 2011). Moreover, Chinese firms have been more aware of using design to create new meaningful offerings (De Bont, 2016; De Bont & Liu, 2017; Liu & De Bont, 2017). In practice, senior managers have shown great interests in following design-related programmes, such as the Executive Master in Meaningful Innovation offered by the Hong Kong Polytechnic University and 'Lead a Creative China 2030' , which is collaboratively provided by Tsinghua University and IDEO.

Considering the extensive efforts paid on design, we start to be curious of the effectiveness of using design to enhance product competitiveness. With great emphasis on how to equip Chinese firms with design capability (Heskett & Liu, 2012; Liu, 2016a), this is the time to assess the effectiveness. Specifically, in comparison to international leading brands, are the products developed by Chinese firms are competitive? If so/not, on what dimensions Chinese firms excel, or fall behind international leading brands? Answering these questions can help us outline the competitiveness of products developed by Chinese firms, which can also reveal the design capability of Chinese firms. To answer these questions, this paper will review the literature on design and competitiveness, develop the research framework, collect and analyse data, and discuss the implications.

2 Literature review: design and product competitiveness

Product competitiveness refers to the degree to which the firms' product offerings are perceived to have a superior fitness for use, in comparison to the competing products in the markets (Luo, 2010; Phillips, Chang, & Buzzell, 1983; Rust, Lemon, & Zeithaml, 2004). In other words, a highly competitive product should provide superior benefits for consumers, which enable the product to stand out from other competitors in the markets. Consequently,

a highly competitive product can enhance consumers' evaluation and their purchase intention. In a long term, a competitive product can facilitate consumers' repurchase intention and brand loyalty (e.g., (Boulding, Kalra, & Staelin, 1999; Keller & Lehmann, 2006; Slotegraaf & Inman, 2004).

The competitiveness of a product depends largely on the benefits of a product. Many studies have decomposed the benefits provided by a product. Having investigated the contribution of design to competitiveness in technology-driven companies, Gemser, Jacobs, and Ten Cate (2006) concluded that functionality, usability, and aesthetic are three key factors related with a firm's design awareness, which further constitute the product competitiveness. Similarly,, Gielens (2012) have investigated the competitiveness of private label brands in comparison to national brands and proposed that benefits provided by a product can be categorized into intrinsic benefits (related with performance quality), extrinsic benefits (related with product appearance and packaging), and usage benefits (related with usability). These studies have indicated that functionality, usability, and aesthetics are generally important factors for product competitiveness.

The area of design research has also decomposed the benefits of a product and extended the previous research through identifying two additional factors. Rampino (2011) analysed a group of products and concluded that relative advantages can be created through creating aesthetic innovations, usage (a.k.a, innovation of use), meaning and typological innovation. These four types of innovation correspond to the four types of benefits of a product. Specifically, aesthetic innovation concerns product recognition, which corresponds to the extrinsic benefits (Gielens, 2012). Usage innovation refers to the improvements of product functions and usability, which correspond to functionality and usability defined by Gemster et al. (2006) and intrinsic benefits labelled by Gielens (2012). Meaning innovation relates to emotional and symbolic aspects of a product. This notion extends on the previous works (Gemster et al., 2006; Gielens, 2012). As explained by Verganti (2009), consumers buy products not only for utilitarian purposes but also for the meanings encoded within products. Thus, through exploring extensively, designers can generate new meanings and encode them into products, and these encoded meanings can contribute to product competitiveness. Typological innovation concerns the deviation of a product from its category archetype. In other words, typological innovation describes the high innovativeness level, which can be triggered by aesthetic innovation, usage innovation and meaning innovation.

Although the identified four types of products are distinct from each other, they are not necessarily exclusive from each other. In fact, they differ from each other in terms of prominence. Taken together, they make a whole offering to consumers. For example, as for the competitiveness of a product, the competitiveness could come from an aesthetically pleasing appearance, easy to use interface, superior functionality, and rich meanings associated with the product at the same time. Among the different sources for competitiveness, one might be more prominent than others.

Back to this study, product competitiveness can come from different sources, such as aesthetic, usage, and meaning innovation. Therefore, in order to investigate the competitiveness of products developed by Chinese firms, we can measure the general competitiveness of products，as well as each source of product competitiveness. Specifically, a product can be analysed on these four dimensions. For example, the twin

drum washing machine is a new product launched into markets by Haier, a Chinese brand (see Figure 1). This product includes two drum washers, which is highly innovative compared to other washing machines on the markets. This innovative function is designed for users who intend to separate laundry for independent washing. This product thus involves a high degree of usage innovation. Next, because its appearance also differs from most washing machines in the markets, it also integrates aesthetic innovation. In terms of meaning innovation, this product does not change the emotional and symbolic aspects of a washing machine, thus it only integrates a low degree of meaning innovation. In terms of typological innovation, the integration of twin-drum makes this washing machine deviate from the category archetype. This washing machine thus also includes a relatively high degree of typological innovation.

Figure 1. The example of a twin drum washing machine developed by Haier

3 The Present Study

This study aims to investigate the competitiveness of product developed by Chinese firms. Following the innovation pyramid framework (Rampino, 2011), we are able to pin down the general competitiveness as well as the competitiveness on specific dimensions. Our research questions are proposed as follows: Are Chinese brands competitive with international leading brands? If so/not, on what dimensions do they excel/fall behind with international leading brands?

Answering these questions can make important contributions. First, few studies have been conducted to understand the competitiveness of products developed by Chinese companies. Since several studies have been conducted to investigate the integration of design in NPD process in Chinese companies (Zhang, Hu, & Kotabe, 2011) and the barriers to utilize the strategic design in Chinese companies (De Bont & Liu, 2017; Liu & De Bont, 2017), time is ripe to assess the results and quality of utilizing design in Chinese companies. Second, while Rampino (2011) proposed the innovation pyramid framework to outline design's contribution to new product development through qualitative methods, it is still to be known whether this research framework is comprehensive enough adequate to capture and explain the product competitiveness. Using this model to investigate Chinese firms' product competitiveness, we can examine the adequacy of this framework to describe product competitiveness. Third,

results of this study can provide additional insights into the gap between Chinese firms and international leading brands, which can offer actionable implications for Chinese firms.

4 Research Design

In order to address the research questions, we collected products that won international design awards (i.e., reddot, iF) for four reasons. First, we believe that companies that developed these award-winning products appreciate the importance and value of design. Another reason for choosing awards-winning products is that these products, selected by design experts, represent the highest quality of design (Self, 2013). Investigating these products allows us to better understand the role of design encoded by companies. Furthermore, as awards-winning products have similar overall design quality, it is possible to conduct a comparable study. In addition, since we intend to compare the product competitiveness between Chinese firms and international leading brands, we collected products developed by Chinese firms and those by international leading brands.

Next, to gain insights into product competitiveness on a specific dimension, we followed Rampino's innovation pyramid framework. We characterize the award-winning products along four dimensions, each of which corresponds to the degree of involving aesthetic innovation, usage innovation, meaning innovation, and typological innovation, respectively. We examine consumer responses to products in terms of their overall evaluation of the products, as well as their evaluation on each of the four dimensions.

Moreover, consumers' evaluation of a product is largely influenced by contextual factors, such as the country-of-origin (COO) effect and consumer's prior experience (Bilkey & Nes, 1982). In general, consumers tend to evaluate products from developed countries (e.g., Germany, Japan, and U.S.) more positively than those from developing countries（e.g., Nigeria, China, and Vietnam, see Yeong, Mohamad, Ramayah, & Omar, 2007), because the former ones enjoy more positive perceptions and images (Hampton, 1977; Krishnakumar, 1974; Schooler, 1971; Tongberg, 1972; Wang, 1978). However, one exception is that consumers tend to evaluate their own country's products more positively than foreigners do (Kaynak & Cavusgil, 1983). For instance, American consumers usually evaluate U.S. products more positively, whereas European consumers evaluate European products over American products (Bannister & Saunders, 1978; Nagashima, 1977). The positive perception of local brands can be triggered by consumers' familiarity with local brands. For consumers who have prior experience with a brand, they tend to be more loyal to the brand than consumers without such prior experience (Ozer, 2011). Consumers' prior experience can be gained either directly through using or trying a product themselves, or indirectly through being exposed to various promotion activities.

Considering the COO effects, this study intends to conduct comparable study (see figure 2 for research model). To do so, we invited participants from different countries to evaluate the products of Chinese firms and those of international leading brands. Based on a comparison of consumers' evaluations of products from Chinese companies and international leading companies, we can learn the overall performance and sub-dimensional performance of Chinese companies in different markets. The results are can enrich the current understanding of the competitiveness of products developed by Chinese brands.

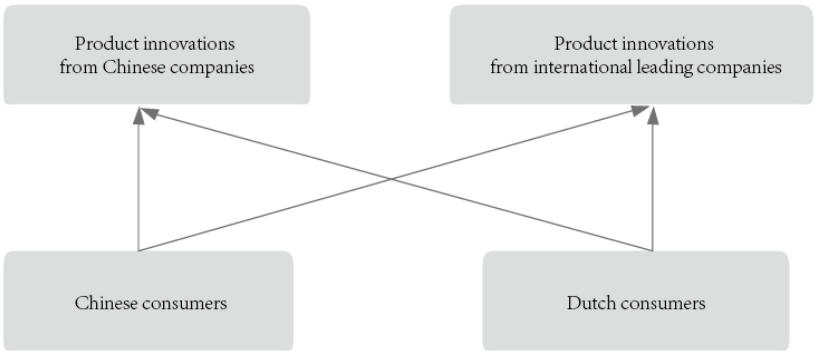

Figure 2. Research model of this study.

5 Methods

5.1 Design and participants

A survey was conducted. The survey used a 2 (product origin: Chinese brands vs. international leading brands) × 2 (consumer origin: Chinese consumers vs. non-Chinese consumers) × 4 (product category: smartphone, cleaning robot, TV, and washing machine) design, with product origin and consumer origin as between-subject factors and product category as within-subject factor.

Two hundred and sixteen participants (mean age = 36.7, 52.7% male) were invited from a consumer panel. Participants were collected from China and Netherlands. Netherlands was selected because it sharply contrasts with China for its smaller size and fewer variabilities. Dutch consumer are also more open to adopting innovations than their counterparts in other European countries (Suriñach, Autant-Bernard, Manca, Massard, & Moreno, 2009) and do not feel reluctant to purchase foreign products (Nijssen & Douglas, 2004).

5.2 Stimuli

Four product categories were collected to improve generalizability: smartphones, cleaning robots, TVs, and washing machines. The market penetration for these product categories is relatively high，leading to the fierce market competition. Brands thus rely on design to gain a competitive edge. Moreover, as these product categories have been mature, consumers possess basic knowledge of these products. Next, for each product category, four products were selected, totalling 16 products. Within each product category, we collected two products from Chinese brands and two products from international leading brands. For each product, the product picture(s), functional descriptions, and the product's origin country constituted stimuli presented to participants.

5.3 Procedure and Measurements

Each participant was assigned to rate products, which are either from Chinese brands or from international leading brands. Each participant evaluated one product from each product category, totalling four products. The order of presenting products was randomized.

The survey was conducted through online research tool Qualtrics. The survey was firstly made and tested in English. Next, the survey was translated to Chinses and Dutch respectively and distributed in these two countries. The size of sample and demographic information were balanced across the two countries.

We measured consumers' overall evaluation of products, consumers' evaluation of aesthetic innovation, usage innovation, meaning innovation, and typological innovation. The measures were based on a 7-point scale from 1 to 7 (see Table 1 for detailed measures).

Table 1. The measures used in the study

Overall Evaluation (Mugge & Dahl, 2013; Zhao, Hoeffler, & Dahl, 2012) α ranged from 0.91 to 0.93
bad/good
negative/positive
unfavorable/favorable
dislike/like
Aesthetic Innovation (adapted from Rampino 2011; Gielens 2012) α ranged from 0.90 to 0.92
The product is easily recognizable.
The product introduces a new look.
The features of product are presented in a new way.
Usage Innovation (adapted from Rampino 2011; Gielens 2012; Zhao, Dahl & Hoeffler 2014) α ranged from 0.92 to 0.95
The product is intuitive to use.
The product introduces new function.
The product offers new features.
What do you think of the technology integrated in the product? not novel / very novel.
Meaning Innovation (adapted from Rampino 2011) α ranged from 0.93 to 0.95
The product is considered a status-symbol.
The product is exciting.
The product introduces new meaning to the product category.
Typological innovation (adapted from Rampino,2011; Veryzer & Hutchinson,1998) *r* ranged from 0.12 to 0.21
How is the product compared with others? - Not typical/very typical - Not usual/very usual.

6 Results

The model constructs were firstly assessed by means of a confirmatory factor analysis (CFA) to examine the adequateness and accuracy of the conceptual model. Next, after the reliability and validity of measured had been confirmed, ANOVA analyses were conducted to reveal the differences between Dutch and Chinese consumers' evaluation of products.

6.1 Reliability and Validity of Measures/Test of the Conceptual Model

The internal consistency and convergent validity of the scales to measure consumers' evaluation of products on aesthetic, usage, meaning and typological dimension was investigated by performing a CFA on all items of the latent variables using ML-estimation in LISREL 8.80 (Jöreskog & Sörbom, 1993). The results indicated a good fit to the data ($\chi 2$ = 542.20, df = 94, $\chi 2/df$ = 5.5; GFI = 0.93, CFI = 0.99, RMSEA = 0.074). Convergent validity was indicated by the fact that the items loaded significantly on their corresponding latent construct (all t's > 2.0) (Bagozzi, Yi, & Phillips, 1991). Discriminant validity among the scales was assessed as follows. First, a baseline model (in which the correlations between pairs of constructs were freely estimated) was estimated for each possible pair of scales. Next, we compared this baseline model to a series of alternative models, in which the correlations between pairs of constructs were constrained to unity (Anderson & Gerbing, 1988). In each case, the constrained model exhibited a statistically increase in chi-square ($\Delta\chi 2$ (1) > 3.84), providing evidence of discriminant validity (Bagozzi & Phillips, 1982). Furthermore, the reliability of each scale was explored by computing the reliability coefficient or Pearson's

correlation (α overall evaluation= 0.96; α aesthetic innovation = 0.91; α usage innovation = 0.95; α meaning innovation = 0.94; r typological innovation = 0.208, p=.002). Taken together, these models present a sufficient degree of reliability and validity (see figure 3).

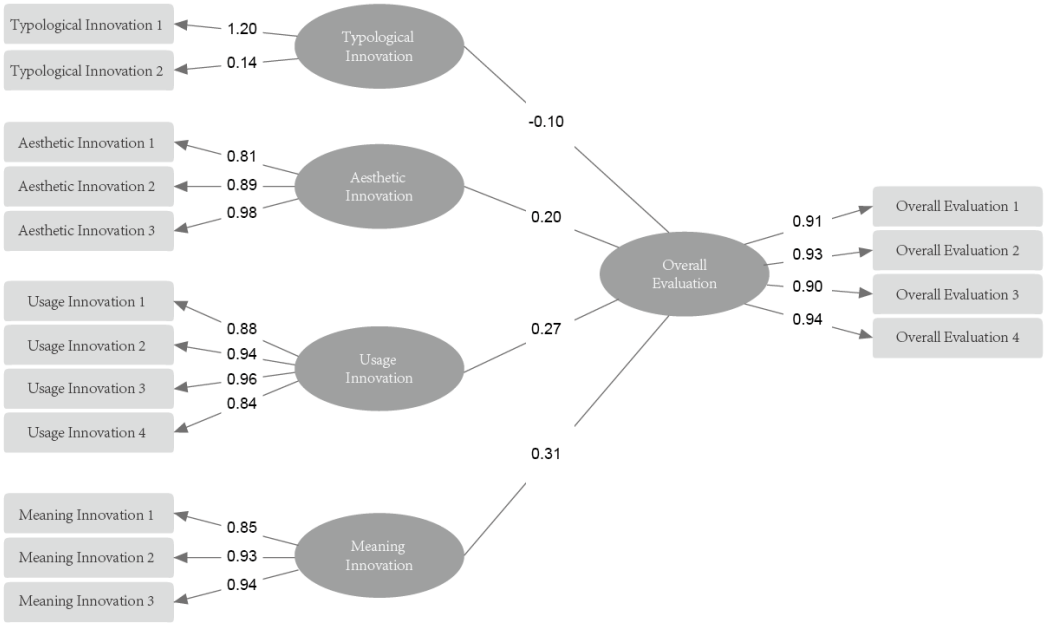

Figure 3. Results of CFA

6.2 Consumers' evaluation of products between different countries

Repeated measure ANOVA was conducted with product origin and consumers' origin as between subject variable, product category as within variable. Results revealed interaction effects between consumers' origin and products' origin on the ratings of overall evaluation $F(1, 213)= 15.72$, $p<0.00$, aesthetic innovation $F(1, 213)= 8.33$, $p<0.01$, usage innovation $F(1, 213)= 7.72$, $p<0.01$, meaning innovation $F(1, 213)= 10.02$, $p<0.01$, and typological innovation $F(1, 213)= 11.58$, $p<0.01$.

Specifically, for Chinese consumers, they reported higher scores for Chinese brands than international leading brands in terms of overall evaluations ($F(1, 112)= 11.73$, $p<0.05$. M Chinese brand = 6.17 vs. M international brand = 5.65), aesthetic innovation ($F(1, 112)= 6.42$, $p<0.05$. M Chinese brand = 5.68 vs. M international brand = 5.20), usage innovation ($F(1, 112)= 8.83$, $p<0.05$. M Chinese brand = 5.87 vs. M international brand = 5.34), meaning innovation ($F(1, 112)= 6.50$, $p<0.05$. M Chinese brand = 5.61 vs. M international brand = 5.10), and typological innovation ($F(1, 112)= 9.79$, $p<0.05$. M Chinese brand = 5.17 vs. M international brand = 4.65), suggesting that Chinese consumers generally perceived Chinese brands more positively than they did with international brands (see Figure 4).

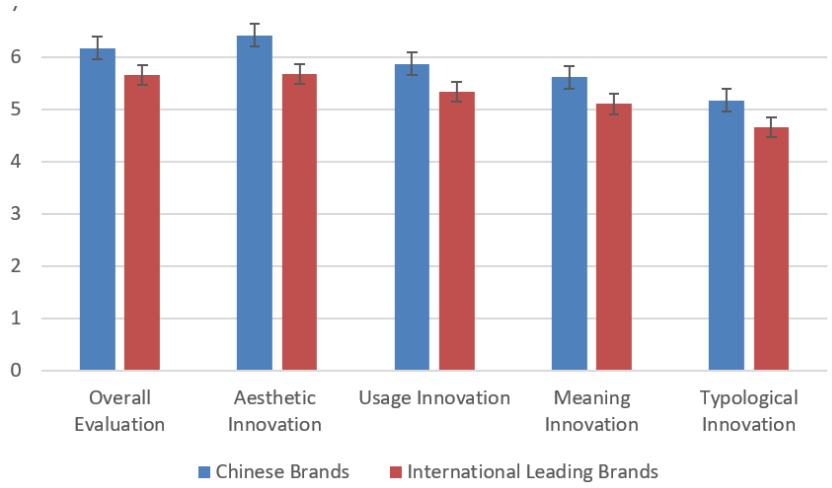

Figure 4. Chinese consumers' evaluation of products developed by Chinese brands and international leading brands.

Different results were found for Dutch consumers. Dutch consumers rated higher scores for international leading brands than Chinese brands on overall evaluation ($F(1, 101)= 5.66$, $p<0.05$. M Chinese brand = 4.71 vs. M international brand = 5.23) and meaning innovation ($F(1, 101)= 4.05$, $p<0.05$. M Chinese brand = 3.79 vs. M international brand = 4.36). No significant differences were found in terms of typological innovation ($p>0.5$), usage innovation ($p>0.1$) and aesthetic innovation ($p>0.1$) between Chinese brands and international brands. The results indicated that Dutch consumers perceived international brands more positively in general and meaning innovation (see Figure 5).

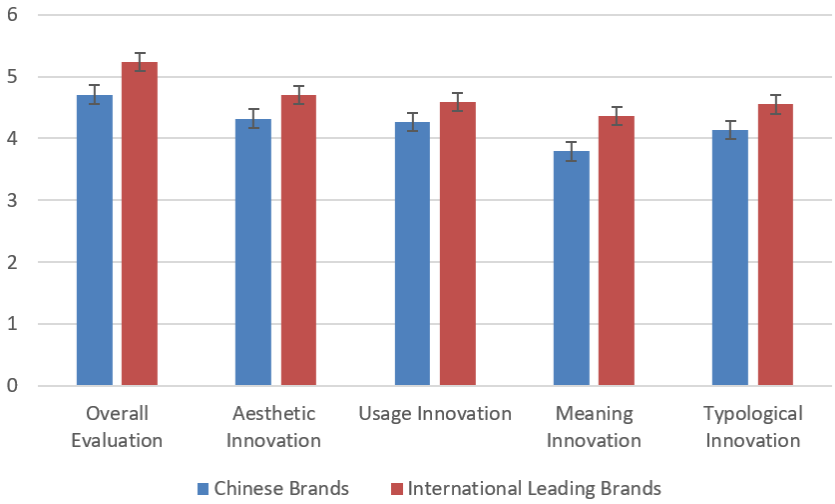

Figure 5. Dutch consumers' evaluation of products developed by Chinese brands and international leading brands.

7 General Discussion

This research investigated competitiveness of products developed by Chinese brands through investigating consumer responses to design awards-winning products. To capture the different sources of product competitiveness, this study follows the innovation pyramid framework (Rampino, 2011) to examine consumers' overall evaluation of products as well as

evaluations on aesthetic, usage, meaning, and typological innovation. Through structural equation modelling, the data reveal a good fit with the proposed conceptual model, which demonstrated the validity and adequacy of four sub-dimensions in innovation pyramid framework in capturing consumers' overall evaluation of products.

Furthermore, the current results reveal Chinese consumers' and Dutch consumers' different evaluations of product innovations from Chinese firms and international leading brands. Specifically, Chinese consumers evaluated Chinese products more positively than international leading brands in terms of overall evaluation, usage innovation, meaning innovation, aesthetic innovation, and typological innovation. As for Chinese brands in Chinese markets, results showed that they perform very well thus far. Chinese consumers used to have an inferior perception for local brands several decades ago (Sklair, 1994). However, our results suggest that such an inferior perception has completely disappeared. Instead, Chinese consumers showed more favourable attitudes towards local brands. It is amazing to see how fast Chinese companies have acquired the design capability in spite of many barriers, leading Chinese firms successfully convince Chinese consumers.

However, the positive impressions of Chinese consumers on Chinese brands could be attributed to COO effects, so it is necessary to understand Dutch consumers' evaluation. Different from Chinese consumers, Dutch consumers evaluated international leading brands more positively than Chinese brands in terms of overall evaluation and meaning innovation. Dutch consumers did not show significant differences between Chinese brands and international leading brands regarding usage innovation, aesthetic innovation, and typological innovation. In other words, in the Dutch market, Chinese brands competitively develop aesthetically pleasing and user-friendly products similar to international leading brands. However, it still takes efforts for Chinese brands to convince Dutch consumers of their ability to develop meaning innovation.

Taken together, these results indicate that Chinese brands are able to utilize design to improve product competitiveness. Chinese firms are demonstrated to be as competitive as international leading companies in using design to create aesthetic and usage innovation in both Chinese and Dutch markets. While Chinese brands perform very well in the domestic market in utilizing design to generate meaning innovation, they do much less so in Dutch market. Chinese firms' different performances in creating meaning innovation can be explained by the difficulty in developing meaningful innovations for foreign markets. The cultural differences pose as a major barrier to developing meaning innovations for another culture.

7.1 Contributions

The current results contribute to the field in several ways. Previous studies have investigated how to stimulate strategic role of design in Chinese firms (Liu, Liu, & Zhang, 2018; Liu & De Bont, 2017; De Bont & Liu, 2017; De Bont, 2016). This study has confirmed the competitiveness of products developed by Chinese companies. the comparison between product innovations developed by Chinese companies and those by international leading brands has demonstrated Chinese brands outperform international leading brands in the Chinese market. However, in western markets, there remain stereotypes. Dutch consumers only believe in Chinese companies' ability to develop usage and aesthetic innovation but not meaning innovations. This finding suggests that Chinese brands need to further persuade

consumers of their ability to develop meaning innovation if they intend to compete with international leading brands in western markets.

Additionally, this study has provided empirical basis for the validity and adequacy of four-dimension in describing different types of product innovations. Since the Rampino's (2011) innovation pyramid was originally developed based on qualitative studies, little quantitative research has utilized this framework to investigate the competitiveness of product innovations. Our results computed through SEM have demonstrated that these four-dimensional model based on the innovation pyramid can serve as effective tools in exploring the role of design as manifested in the characteristics of products.

7.2 Practical Implications

Our findings have implications for Chinese brands interested in launching their products in western markets. The western markets are relatively mature, where consumers hold certain perceptions. Western consumers, as represented by the Dutch consumers in this research, are prepared to accept aesthetic and usage innovations generated by Chinese brands; however, they are yet convinced of Chinese companies' innovation at the higher level of the pyramid, namely meaning innovation and overall innovation. Chinese brands need to invest greater efforts to utilize the strategic role of design to develop meaning innovation.

To develop meaning innovation, companies need to develop a standard design-led process to lead NPD process (Heskett & Liu, 2012). In this respect, design-driven innovation strategy can be particularly helpful (Verganti, 2009). Accordingly, product development teams should explore at a greater depth the hidden and unspoken meanings in sociocultural contexts. The design-driven innovation process significantly differs from the traditional user-centred design process, which requires product development teams to be close with end-users, be sensitive to their needs, and be creative to propose solutions. The networked process demands the new product development team to work with key interpreters, share knowledge, and propose unique meanings. The interpreters include designers, architect, users, artists, etc who are interested in understanding the meanings embedded in current sociocultural context, as well as proposing meanings for future sociocultural context. Collaborating with these interpreters to explore, share, and internalize knowledge on meanings are likely to create products with desirable meanings.

Moreover, companies need to be aware of the difficulty in developing meaningful product innovations for foreign markets. The cultural context largely shapes consumers' perceptions and experience of the meaning encoded in a product innovation. What is considered meaningful in one cultural context is not necessarily so in other cultural contexts. To address this challenge, companies need to understand a distant cultural background, interpret it properly and develop meaningful product innovations accordingly. In this respect, it is helpful to deploy of cross-culture design toolkits to go beyond individual perspectives and establish a shared understanding and empathy with users in a distant cultural background (Hao, van Boeijen, Stappers, & Alberto, 2017; Postma, 2012; van Boeijen, 2015).

These findings also offer implications for international leading brands interested in Chinese markets. Chinese consumers used to believe that international brands are superior to local brands (Sklair, 1994) and many Chinese firms used to imitate western brands. Given such presumptions, international leading brands used to occupy large market shares in Chinese markets. However, with the rising of Chinese brands, the advantages of international leading

brands may fade out (Laforet & Chen, 2012). Results of this research reveal that consumers do not associate superiority with international leading brands in Chinese markets. Therefore, international leading brands should consider how to compete with local brands.

7.3 Limitations & Future research

There are several opportunities to strengthen this research. In this study, we compared Dutch consumers' and Chinese consumers' evaluation of products from international leading brands and their evaluations of products from Chinese brands. We selected Dutch consumers to represent consumers in western countries because Netherlands is a small country with few varieties and Dutch consumers tend to be more open to adopt foreign products. However, in future research, it would be valuable to replicate this study in other countries (e.g., U.S.) to strengthen the conceptual model. Moreover, to ensure the generalizability, this study involves four product categories with high market penetration. It would be interesting to examine consumers' evaluation with product categories, which are in the early stage of product life cycle.

There are additional factors influencing product competitiveness in the markets, such as product price and manufacturing costs, but we focused only on the benefits provided by a product. Future research should consider other factors determining product competitiveness and examine product competitiveness in Chinese firms in general. Moreover, we investigated product competitiveness from consumers' perspective, it would be interesting for future research to take a firm perspective through measuring business performance, such as revenue, profit, and revenue growth (Manoochehri, 2010), which will deepen our understanding of the design's contribution to firms' financial performance.

Moreover, although this study reveal Chinese consumers' positive impression of products developed by Chinese firms, we should be aware that the selected products are awards-winning ones, which represented the highest quality but may not indicate the average design capacity of majority Chinese firms. In other words, the most SMEs may not be equipped with the similar level of design capability. Thus, we expect more research on investigating the products developed by most SMEs and understand the average design capability of Chinese firms.

Furthermore, the stimuli selected in this study are products. However, design can contribute to product development, as well as service development. In fact, Chinese Internet industry is prosperous and many Chinese firms emphasize the development of meaningful service innovation. For example, targeting UK markets, TrainPal is an App run by Chinese firms. TrainPal is developed to help consumers buy train tickets in the cheapest and fastest way. By adopting specialized algorithms, TrainPal can segment a journey into different parts and search for the most suitable solution, helping consumers save 30% of the cost. Considering TrainPal has become the most popular App in UK in 2018, researchers should consider investigating the product competitiveness and capabilities in service innovation context, to broaden our understanding of the competitiveness of design in Chinese companies.

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Less for more, but how & why? – Number of elements as key determinant of visual complexity

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Although designers aim at “less for more” when developing a product, they struggle with how to achieve simplicity and why making a product simple improves the commercial value of the product. To answer the two questions, we performed one experimental study. In the study, we searched for which of the six different types of lowering visual complexity is effective and examined whether authenticity mediates the effect of visual complexity on commercial value. Results show that three out of six types of lowering visual complexity (e.g., irregularity of arrangement, amount of material, incongruity) deemed to be more commercial value. Results also show that decreasing the amount of material is the only way to enhance authenticity, which in turn increases the commercial value of the product.

Keywords: Visual complexity, Authenticity, Commercial value

1 Introduction

“Less for more” is a popular saying among designers. This design tendency is also evident in the principles and philosophies of influential designers. It led the “less is more” movement in architecture characterized by the works of Mies van der Rohe. It introduced “white space” in advertisement originated from a famously simple IBM block logo designed by Paul Rand (Pracejus, Olsen, Guinn, Olsen, & Guinn, 2006). This tendency also resulted in the commercial success of the consumer electronics designed by Dieter Rams in Braun, who introduced “good design is as little design as possible.” (Lovell, 2011). He argued that a product is beautiful when it has a few basic geometric shapes with non-fussy colors. His approach later inspired Jonathan Ive, who has designed a wide variety of highly popular electronic products at Apple.

Designers have a consensus about what is simple. The common design style ‘simple’ corresponds to prior research that has demonstrated a general preference towards objects and designs that are symmetric, unified, and have low complexity (Berlyne, 1970; Hekkert & Leder, 2008; Hutchinson, 1998). Complexity is a design attribute that is used by designers which are opposite (and therefore correlated) to the attribute simplicity (Blijlevens, Creusen, & Schoormans, 2009).

However, package designers often struggle with how to achieve simplicity and are not fully informed about why making a product simple improves commercial value in package design.

For instance, simplicity was identified as the appearance attributes that consumers in general use to distinguish between different product appearances (Blijlevens et al., 2009). Therefore, simplicity is related to a product's competitiveness, which can lead to commercial value. Most designers would agree that simplicity is a virtue in design. However, the nature of this simplicity has yet to be clearly elucidated (Shelley, 2015). Also, most approaches and methods aimed at reducing complexity in some way, but reducing design complexity is not an easy task (Stolterman, 2008).

Therefore, this research has two purposes. Note that answering each purpose benefit different groups of people. First, we aim to answer "How can we decrease visual complexity?" Answering this question will benefit designers. In the past, designers have achieved simplicity in many different ways. Some have done decreasing the amount of embellishments in fashion (Cox & Cox, 2002) and others have done simplifying shapes in car design (Lee, Jung, & Chu, 2015). In general, practical knowledge about decreasing visual complexity in package design has not been established.

Second, we aim to answer "Why does decreasing visual complexity of a package design improve the commercial value of the product?" Answering this question will benefit managers. In the past, studies regarding how visual complexity affects commercial value of the product were scarce. Therefore, practical knowledge about decreasing visual complexity needs in-depth research.

In the prior literature, decreasing visual complexity has been found to be advantageous in processing information (Reber & Schwarz, 2004). This metacognitive advantage is believed to benefit commercial value, suggesting that decreasing visual complexity is rather a non-cognitive advantage. In this research, we argue there is another cognitive reason why doing so increases commercial value.

2 Theory

2.1 Visual complexity

Visual complexity is narrowly defined as the amount of detail or intricacy of lines in the picture (Snodgrass & Vanderwart, 1980). A broader definition of visual complexity comes from Berlyne, an experimental psychologist who investigates complexity, arousal, and preference. According to his research (1958), there are six different types (ways) of increasing or decreasing visual complexity.

- (VC_A) *Irregularity of arrangement*: the elements are arranged in an irregular geometrical pattern and irregularly scattered (Berlyne, 1958). For instance, an image containing an irregular geometrical pattern is visually more complex than an image with a regular geometric al pattern.
- (VC_B) *Amount of material*: the amount of elements is arranged as independent visual elements. For instance, an image containing more lines is visually more complex than an image with fewer lines (Peckham, 1966).
- (VC_C) *Heterogeneity of elements*: the same number of different elements in a similar spatial arrangement (Berlyne, 1958). For instance, when a picture consists of a circle, triangle, and square, it is visually more complex than a picture with multiple circles only.
- (VC_D) *Irregularity of shape*: is the nonsymmetrical shape arrangement. For instance, nonsymmetrical shape is more complex than regularity of shape, regularity of contour

and symmetry. Regularity of contour and symmetry imply similarity of parts and predictability of changes in curvature, all of which means high redundancy (Berlyne, 1958)

- (VC_E) *Incongruity*: an unusual arrangement as a picture of a normal animal and a picture of an incongruous animal, i.e., one with parts appropriate to different species or with three heads (Berlyne, 1958). These are closely related to Gestalt characteristics of a product. For instance, when a picture shows a bird's head with a cat's body, it is visually more complex than a picture of either a bird or a cat (Berlyne, Craw, Salapatek, & Lewis, 1963).
- (VC_F) *Incongruous juxtaposition:* this arrangement bears the same material but with the halves of the two objects incongruously juxtaposed (Berlyne, 1958). For instance, when the halves of flowers and the halves of airplane incongruously juxtaposed, it is visually more complex than when either the flowers or the airplanes are placed in an isolated way.

Much prior research has shown that visual complexity influences the psychology of people. When it increases, people increase their attention, interest, and looking time (Eisenman, 1966; Geissler, Zinkhan, & Watson, 2006; Morrison & Dainoff, 1972; Peckham, 1966). For instance, consumers respond more favorably when they watch moderately complex websites than simple or highly complex websites (Geissler et al., 2006). Consumers look at visually complex advertising for longer periods of time (Morrison & Dainoff, 1972). Indeed, visual complexity critically influences people's first impressions, emotions, and aesthetic preferences concerning the stimuli (Berlyne, 1970; Cox & Cox, 2002). For instance, (Cox & Cox, 2002) showed consumers' preferences for visually complex product designs increase with repeated exposures whereas their preferences for visually simple product designs do not. Berlyne (1971) claims that the visual complexity of a product determines its arousal potential, which determines people's arousal response to it. Especially minimalistic package design will positively affect the product's perceived quality and premium perceptions. An example comes from the Sourcy Pure Blue bottle. This bottle is minimalistic and thus premium because it has a basic shape and does not feature any superfluous visuals or text. In contrast, the Aquapax package and the complex shape of Tŷ Nant associated the extensive illustrations and considered less premium water brands (Mugge, Massink, Hultink, & Berg-, 2015).

Differently from what has been discussed in the prior research, based partially on Geissler et al. (2006), we propose that decreasing visual complexity of a product increases the commercial value of the product.

- H1: If the visual complexity of a product decreases, its commercial value will increase.

2.2 Authenticity

'Authentic' implies that the product design refers to a historical, original source, and has been created within that particular context (Snelders, Mugge, & Huinink, 2019). Authenticity is widely acknowledged as a critical dimension for consumers that can be assessed along dimensions such as product styling, connections to a particular location, and firm values (Newman & Dhar, 2014). For example, the Gem paper clip - firstly introduced in the early

1870s - is nowadays considered a classic because it is the oldest and the most practical paper clip model, setting the world standard from the very beginning (Snelders et al., 2019).

Authenticity is an important variable in contemporary marketing (Belk, Costa, & Costa, 1998; Holt, 1997; Kozinets, 2001) and has been garnering increasing attention in the literature (Ilicic & Webster, 2014). As a result, different definitions referring to different types of authenticity have emerged (Valsesia, Nunes, & Ordanini, 2016).

Interestingly, authenticity widely appears in the marketing literature, but only a few design researchers have investigated it. For instance, in craft design, the knowledge of the touch of the human hand makes the product more valuable than a machine-made one because of its authenticity (Kälviäinen, 2000). In textile design, It is considered to render textile design relevant and is a determinant of the level of its craftsmanship (Valentine, Ballie, Robertson, Bletcher, & Stevenson, 2017).

In the present research, we claim that when the visual complexity of a product decreases, the authenticity of the product increases. Our claim is supported by two cases. First, consider the introduction of the original Bondi iMac in 1998. The new iMac was to be the design that re-introduced the public to Apple design, as Steve Jobs envisioned it. It turned out, however, that the design of the Bondi iMac contained an unwelcome surprise for him, in the form of a CD drive with a loading tray (Shelley, 2015). For the user, a CD drive with a tray is more complex than a CD drive with a slot. The tray has a button that the user must push in order to unlatch it. Once the tray is unlatched, the user pulls it out, places a CD in it and pushes it to close. By contrast, the CD slot has no tray and no button. From the user's perspective, it is simply a hole into which CDs may be pushed and from which they may be pulled upon ejection. So, the slot drive is more minimal and thus better than the tray (Shelley, 2015). Second, for a company like Bang & Olufsen, heritage and craftsmanship are vital parts of the brand – even such traits are concepts often perceived concerning authenticity (Sommer, 2012). In order to enhance the authenticity, Bang & Olufsen's focus on simplicity and style as a brand is something that can be seen in everything they do. While B&O believes that beauty is important alongside function, they do not over-work their designs. Instead, they take a minimalist approach (Hodgson, 2017).

In the prior research decreasing visual complexity increases processing fluency (Reber & Schwarz, 2004). The authors proposed that processing fluency, the speed, and ease at which one processes information, was positively related to people's aesthetic judgment of objects. When visual complexity increases, the salience of the source of perceptual fluency decreases, enhancing the misattribution of fluency to beauty. However, further increases in complexity will eventually reduce processing fluency, leading to a decrease in perceived beauty (Reber & Schwarz, 2004). As a result, a decrease in visual complexity allows for easy processing of visual information, which results in high preference.

In contrast, we propose that visual complexity influences the authenticity of the product, which enhances its commercial value. Put simply, differently from the prior research suggesting that people like a visually simple product because visual simplicity relieves the cognitive burden; we argue that people like a visually simple product because, they think, it is perceived to be authentic.

- H2: Authenticity mediates the relationship between visual complexity and commercial value.

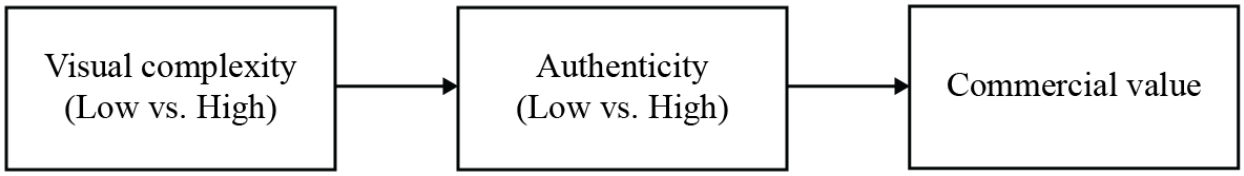


Figure 1: Research framework

3 Study

3.1 Objective

We tested hypotheses 1 and 2. We decreased the visual complexity of an eyeshadow palette package design in multiple ways to examine which way increases the commercial value of the product (H1). We also examined whether decreasing visual complexity of an eyeshadow palette package design increases its commercial value through its enhanced authenticity (H2).

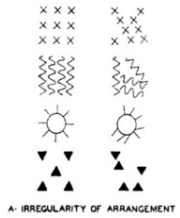
3.2 Design

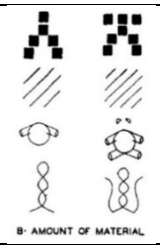
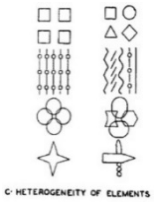
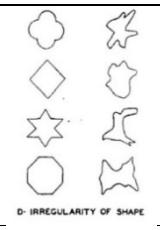
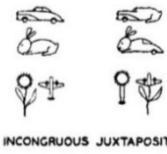
In this study, we employed a 7 (0 vs. VC_A vs. VC_B vs. VC_C vs. VC_D vs. VC_E vs. VC_F) between-subjects design.

3.3 Stimuli

We selected an eyeshadow palette as a baseline stimulus and then manipulated its visual complexity in six different ways. The product of the Korean cosmetic company ARITAUM - eye shadow palette (=0) - was chosen because it met all the conditions of visual complexity (Berlyne, 1958), and also presents several visual elements. Furthermore, if Korean cosmetics are used as stimulus, it can be applied directly to the sensitive Korean cosmetics market. A trained designer created digital 2D models of eyeshadow palette package and manipulated the shape of the stimuli following the six different types of lower visual complexity. The brand name was removed to eliminate the brand effect (see Table 1).

Table 1: Six types, manipulations, and stimuli of visual complexity

Types	Type of visual complexity based on Berlyne (1958)	Manipulation	Stimuli
0	-	-	
VC_A		Compared with the control, the manipulated product presents the elements watermelon slices and seeds arranged in a regular geometrical pattern	

VC_B		Compared with the control, the manipulated product removed some watermelon slices and seeds at once	
VC_C		Compared with the control, the manipulated product presents the same number of identical elements (watermelon slices and seeds) in a similar spatial arrangement	
VC_D		Compared with the control, the manipulated product presents watermelon slices and seeds with regularity of shape, regularity of contour and symmetry.	
VC_E		Compared with the control, the manipulated product presents a congruous picture combining watermelon slices and seeds.	
VC_F		Compared with the control, the manipulated product presents watermelon slices and seeds placed in an isolated way	

3.4 Procedure

This experiment was conducted for 14 days from January 10 to January 24, 2019, at a university located in Seoul, Korea. We recruited 254 female students. Since male students rarely use eye shadows, we avoid them. We approached them using SNS advertisements.

We used Qualtrics to design an online questionnaire and collect responses. We wrote questions in both English and Korean to prevent misunderstanding. Participants received one of the seven questionnaires randomly (0 vs. VC_A vs. VC_B vs. VC_C vs. VC_D vs. VC_E vs. VC_F). Note that the specifications of the eye shadow palette were provided equally to the whole participants.

3.5 Measure

To test whether our manipulations were successful, we measured perceived complexity of the product as well as asked a specific question for each product. First, perceived complexity was measured by two questions on 7-point scales anchored by complicated-simple (1 =

complicated, 7 = simple) and simple-complex (reverse coded) (1 = simple, 7 = complex) (Cox & Cox, 2002): '1. How simple does this product look like?; 2. How complex does this product look like?.' Second, we asked a specific question in each condition. After realizing the questionnaire (Cox, 2002) was insufficient to measure the six conditions, we developed based on Berlyne (1958). It was measured on 7-point semantic differential scales anchored by few-a lot (1 = few, 7 = a lot), regular-irregular (1 = regular, 7 = irregular), homogeneous-heterogeneous (1 = homogeneous, 7 = heterogeneous), and symmetrical-asymmetrical (1 = symmetrical, 7 = a symmetrical) (Peckham, 1966): '1. How many design elements does this product have?; 2. Are the design elements of this product irregular (not even or balanced in shape or arrangement)?; 3. Are the design elements of this product heterogeneous (diverse in character or content)?; 4. Are the design elements of this product asymmetrical (having parts or aspects which are not equal or equivalent)?' The coefficient alpha for the measurement scale was .78.

The authenticity was measured by one question on one 9-point semantic differential scale anchored by inauthentic-authentic (1 = inauthentic, 9 = authentic) (Newman & Dhar, 2014): '1. When you think about what it means to be truly authentic product, you would have to say that this product is…'

Finally, the commercial value consists of the sum of purchase intention and willingness to pay. Purchase intention was measured by three questions on 7-point scales (1 = strongly disagree, 7 = strongly agree) (Putrevu & Lord, 2014): '1. It is very likely that I will buy this product; 2. I will purchase this product the next time I need a product; 3. I will definitely try this product.' Regarding willingness to pay, it was measured by two questions on a 9-point scale anchored (1 = would not pay a premium, 9 = would pay a premium) (Newman & Dhar, 2014): '1. How much would you be willing to pay for this particular product relative to the average product?; 2. How likely would you be to purchase this particular product?' The coefficient alpha for both measurement scales was .87.

4 Results

4.1 Manipulation check

Multiple independent t-tests were performed in order to test whether visual complexity was manipulated as intended. Data suggest that five products (VC_A, VC_B, VC_C, VC_D, and VC_E) were successfully manipulated and one product (VC_F) failed to be manipulated. More specifically, participants responded that when the product has a regular arrangement (M_0=4.640 vs M_{vcA}=2.707, t(52)=4.011, p<0.01), when the product has fewer materials (M_0=4.640 vs M_{vcB}=2.260, t(48)=5.260, p<0.01), when the product has homogeneous elements (M_0=4.640 vs M_{vcC}=2.760, t(48)=3.788, p<0.01), when the product has a regularity shape (M_0=4.640 vs M_{vcD} =2.518, t(51)=4.479, p<0.01), and when the product has a congruent element (M_0=4.640 vs M_{vcE} =2.900, t(48)=3.801, p<0.01), it was considered visually less complex than the original product which was not manipulated. However, when the visual elements are congruously juxtaposed, doing so failed to decrease perceived visual complexity.

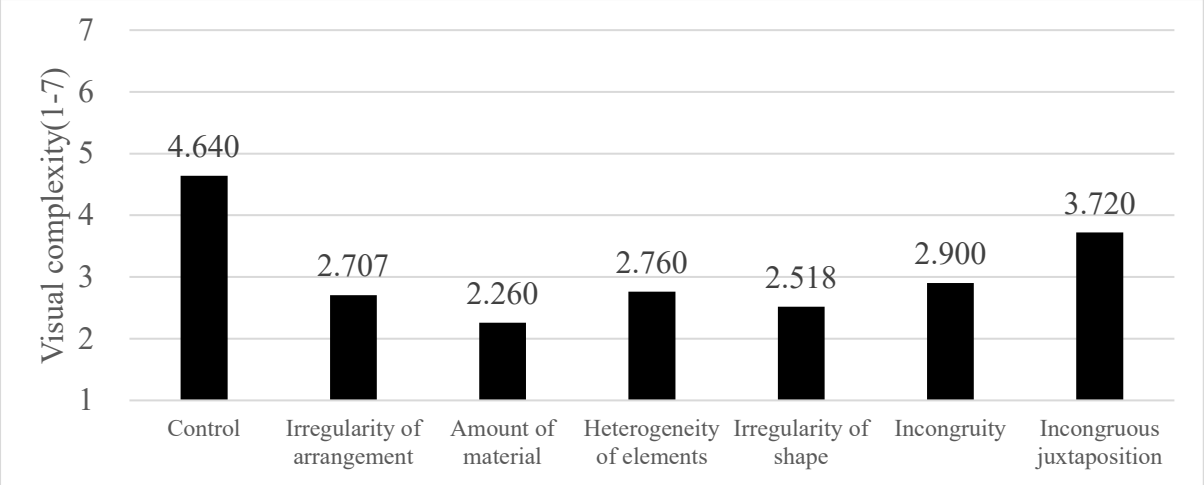


Figure 2: Mean scores of visual complexity

4.2 Commercial value

Independent t-tests were performed in order to test H1. Data suggest that three products (VC_A, VC_B, and VC_E) were significantly higher than control. More specifically, participants responded that when the product has a regular arrangement (M_0 =2.952 vs. M_{vcA} = 4.427, t(52) = 4.351, p<0.01), when the product has fewer materials (M_0=2.952 vs. M_{vcB}= 4.440, t(48)= 4.430, p<0.01), when the product has a congruent element (M_0=2.952 vs M_{vcE} =3.984, t(48)= 3.296, p<0.05), and when there are three types of lower visual complexity (VC_A, VC_B, and VC_E) it increased the commercial value of the product whereas the other three types (VC_C, VC_D, and $VC_{F)}$ failed to increase its commercial value.

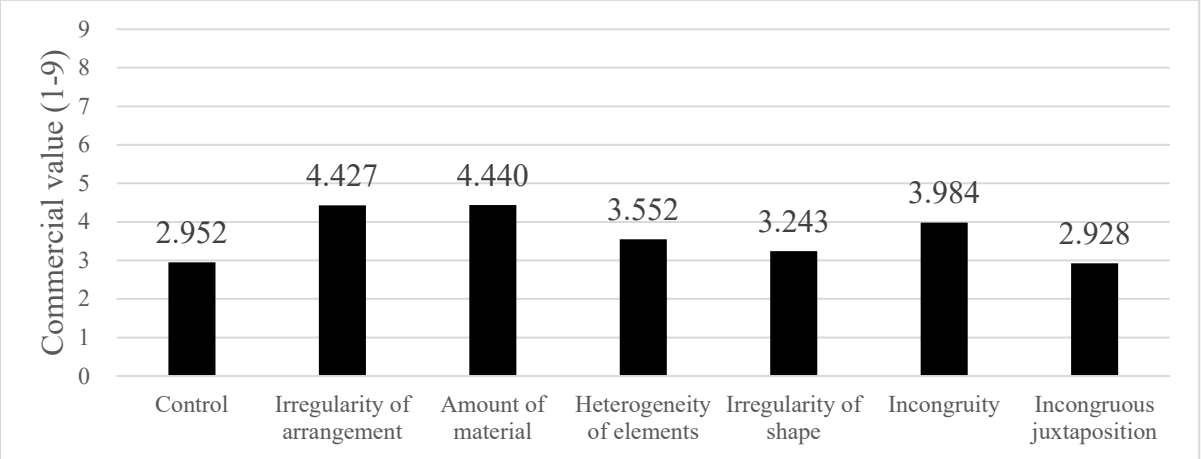


Figure 3: Mean scores of commercial value

4.3 Authenticity

Independent t-tests were performed in order to compare the difference in the mean scores of authenticity. Data suggest that three products (VC_A, VC_B, VC_E) were significantly higher than control. More specifically, participants responded that when the product has a regular arrangement (M_0 = 3.800 vs. M_{vcA} = 5.172, t(52) = 2.959, p<0.01), when the product has fewer materials (M_0=3.800 vs. M_{vcB}=5.240, t(52)=2.586, p<0.01), and when the product has a congruent element (M_0=3.800 vs. M_{vcE} =4.880, t(48)=2.247, p<0.05), the three types of lower visual complexity (VC_A, VC_B, and VC_E) increased the authenticity of the product whereas the other three types (VC_C, VC_D, and $VC_{F)}$ failed to increase its authenticity.

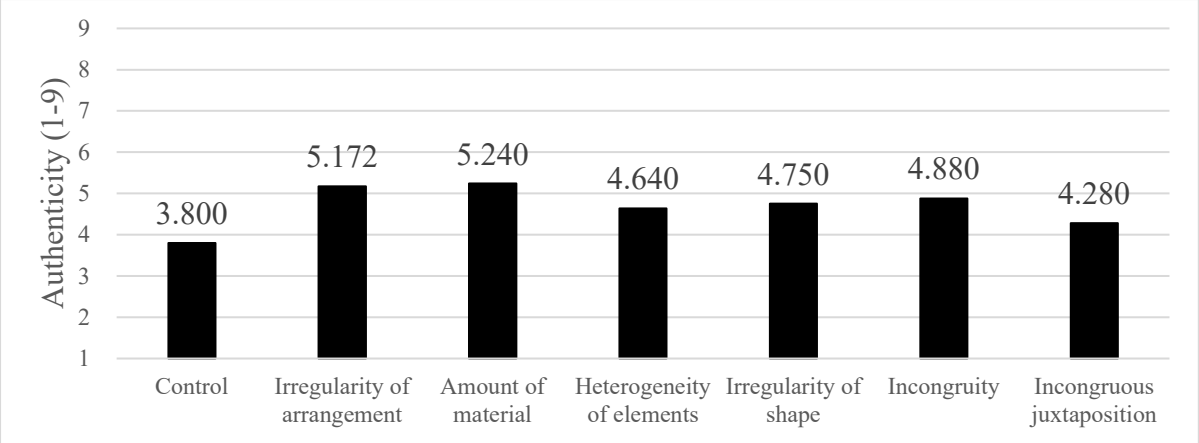


Figure 4: Mean scores of authenticity

4.4 Mediation analysis

To test H2, data were analyzed using Hayes' (2013) PROCESS Model 4 for simple mediation with 5,000 bootstrap samples and a bias-corrected 95% confidence interval. The analyses were performed for commercial value as the dependent variable, with visual complexity as the independent variable and authenticity as the mediation.

As a result of the analysis, we confirmed that only the VC_B is mediated through authenticity. It can be judged statistically significant when 0 does not enter the confidence interval at 95% level. The direct effect of visual complexity on commercial value was -.382, which was not statistically significant. The indirect effect of visual complexity on commercial value was -.238, which is statistically significant. The effect on the visual complexity to commercial value is fully mediated by the authenticity (see Table 2).

Table 2: Total effect, direct effect, and indirect effect of visual complexity on commercial value.

Total effect visual complexity on commercial value					
effect	SE	LLCI	ULCI	t	p
-.619	.230	-1.096	-.142	2.685	.013*
Direct effect visual complexity on commercial value					
effect	SE	LLCI	ULCI	t	p
-.382	.185	-.766	.003	2.060	.051
Indirect effect visual complexity on commercial value					
effect	Boot SE	Boot LLCI	Boot ULCI		
-.238	.130	-.548	-.032		

5 Findings

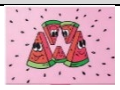
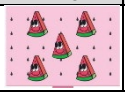
Our experiment produced in total three findings. First, decreasing visual complexity differently results in different degrees of commercial impacts. For instance, five types of lower visual complexity (VC_A, VC_B, VC_C, VC_D, and VC_E) could decrease the perceived visual complexity whereas one type failed to do so (see Table 3).

Second, the effect of visual complexity on commercial value depended on the type of visual complexity. For instance, three types of lower visual complexity (VC_A, VC_B, and VC_E) increased the commercial value of the product whereas the other three types (VC_C, VC_D, and $VC_{F)}$ failed to increase its commercial value. Regarding the three types of lower visual complexity (VC_A, VC_B, and VC_E), because of their simple design, we conjecture people are more familiar than those other three types (VC_C, VC_D, and VC_F). This implies that three types

of lower visual complexity (VC_A, VC_B, and VC_E) can improve the commercial value differently.

Third, the results of the mediating effect of authenticity provide important insights into the role of authenticity in the effect of visual complexity on commercial value. They show that VC_B is the only way to decrease visual complexity, which increases commercial value through enhanced authenticity

Table 3: Statistically significant visual complexity type by variable

Type		Control	VC_A	VC_B	VC_C	VC_D	VC_E	VC_F
Stimuli								
IV	Visual complexity	4.640	2.707**	2.260**	2.760**	2.518**	2.900**	3.720
DV	Commercial value	2.952	4.427**	4.440**	3.552	3.243	3.984*	2.928
MeV	Authenticity	3.800	5.172**	5.240**	4.640	4.750	4.880*	4.280

*p< 0.05 **p< 0.01

6 Discussion

In conclusion, this study has academic significance showing that visual complexity (high vs. low) affects commercial value through authenticity, which has not been actively discussed in the existing visual complexity studies. Although authenticity appears in some marketing research, it is interesting that in this study we have found that visual complexity can affect authenticity.

The results of this study support our hypotheses. As expected, package design in the high level of visual complexity is less commercial than package design in the low level of visual complexity (H1). Moreover, a mediation analysis shows that this effect of visual complexity on commercial value is mediated by authenticity (H2).

7 Theoretical implications

In this study, we showed that visual complexity influences the authenticity of the product, which enhances its commercial value. Our findings differ from the prior research arguing that aesthetic pleasure depends on the perceivers' processing dynamics (Reber et al., 2004). Prior research suggests that cognitive load caused by a lot of information leads to a decrease in processing fluency (Reber & Schwarz, 2004). High cognitive load and low processing fluency decrease preferences for products. Differently from the prior research suggesting that people like a visually simple product because it relieves cognitive burden, we demonstrated that people like a visually simple product (VC_B - fewer materials) because it is perceived to be authentic. In summary (Figure 5), prior studies suggest a metacognitive mechanism in which lowered visual complexity positively influences observers' process fluency. But this study suggests a cognitive mechanism that lowers visual complexity, positively influences observers' authenticity.

This research is meaningful because it has further proposed cognitive mechanisms in relation to product preferences. In other words, although prior studies say that the preference for products depends on the observer's processing fluency, the product's authenticity is also academically meaningful, and it can be considered an important mediator.

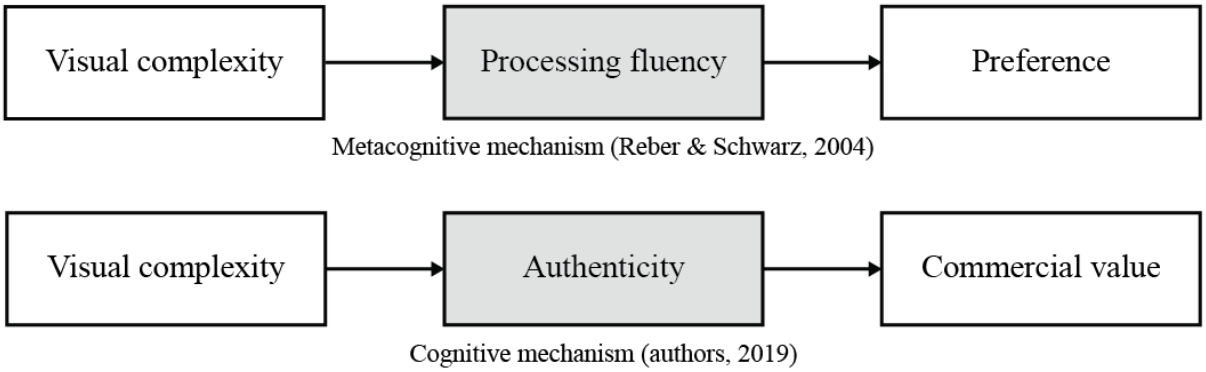


Figure 5: Compared metacognitive and cognitive mechanisms

8 Practical implications

Our findings have practical implications for answering how and why decreasing visual complexity.

First, this research provides practical knowledge helping designers in developing a visual design strategy for their products. This study verified that consumers respond differently to visual complexity in a package design depending on their types. This implies that all types of lower visual complexity can be appealing to consumers differently, and the six types of lower visual complexity (Berlyne, 1958) should be applied differently depending on the circumstances.

Designers have a consensus about what is simple. But they rely on their senses for their simple designs. This research suggests six different types of lower visual complexity and how to decrease it, and quantitatively provides them with what is effective. Therefore, designers can use separately effective methods for decreasing visual complexity.

For instance, designers and managers need to pay attention to irregular arrangement, amount of material and incongruity to improve commercial value. Furthermore, this study verified that consumers respond differently to visual complexity in a package design depending on their level of authenticity. Therefore, designers need to consider the importance of authenticity and to do this; they consider reducing the amount of visual material.

Second, this study provides practical knowledge helping managers in developing a marketing strategy. In this study, we have extracted an effective way of using lower visual complexity. Considering this, managers need to attract consumers' attention by using appropriate visual complexity based on irregular arrangement, amount of material, and incongruity. Thereby, drawing an arousal response from consumers and encouraging them to experience excitement and to focus on the product. Furthermore, this study verified that consumers respond differently to visual complexity in a cosmetic package design depending on their level of authenticity. Those with authenticity - cosmetic package design with low visual complexity - were found to have greater commercial value than those with high visual complexity.

9 Research limitations

This study has several limitations, but if we overcome these limitations step by step, we can expect interesting future research.

First, cosmetics vary in types, but in this study, it was difficult to deal with various characteristics of cosmetics by limiting experimental stimulus to ARITAUM's eyeshadow pallet. For example, even if it is the same cosmetic line, the commercial value can be affected differently depending on the product type. In future research, we will need to make use of a variety of product line to make more comprehensive research.

Second, the results of this study have demographic limitations. The study participants were limited to female students. Because male students rarely use eye shadows, we avoid male participants. If we conduct further research on more diverse groups, we can draw more generalized conclusions theoretically and practically.

Third, this study is expected to be an important variable in how sensitive it is the design of a product. In other words, if participants have a major in design or related people, they can increase their authenticity because it is accepted positively when they see a simple product. In additional experiments, participants should review how familiar they are with the field of design.

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Mobilising Publics: Governing Biodesign Technologies

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Biodesign technologies enable us to design a living system and observe how that system and its environment transform over time by analysing, editing, and (re)constituting biological materials. This project creates a new mobile, tangible, and approachable design product to speculate and explore uncertain futures as well as ambiguous ethical issues related to biodesign technologies. To involve multiple and mobile publics, we selected two art festivals held at Sado Island, Japan, and recorded the feelings, thoughts, and views of various audiences through visual thinking strategies (VTS). Our project mobilised both human participants and biomaterials, (social) media services, exhibition spaces, and the culture and environment of Sado Island. Considering the future governance of biodesign technologies allowed us to blur and transgress the boundaries between nature and artefact and between designers and the designed.

Keywords: biodesign, mobile publics, visual thinking strategies, mobility, public engagement

1 Introduction

1.1 Project outline

While the typical acronym used to understand the implications of emerging technologies is ELSI (ethical, legal, and social implications), we turned this on its head, naming our project ‘Innovation for Society, Life and Ethics’ (ISLE). While ELSI research often leaves scientists, decision-makers and citizens with negative impressions of scientific development (Balmer et al., 2015), our project aims to foster proactionary approaches to emerging biomedical research by portraying both its positive and negative societal aspects. Under the Japanese government funding initiative for evidence-based policy making, this project also intends to serve part of the policymaking by collaborating with wider stakeholders and providing available evidence for biodesign technology policy. From a design perspective, a good entry point for a diverse range of people to engage in our project would be a tangible, mobile, approachable product paired with visual images. However, conventional speculative bioart works are somewhat critical of the commercial development of technologies and convey a rather straightforward, unambiguous message. Therefore, it is important to articulate the kinds of visual images that can be used to speculate on and explore uncertain futures and vague ethical issues.

This paper first introduces biodesign technologies and examines the role of publics in design as the key concept of our project. Chapter 2 presents how we applied visual thinking strategies in meta-design and introduces the product design of a pop-up book on biodesign technology. Chapter 3 shows how we designed and organised public events including citizen science, pop-up talks, and workshops for the designed product at two art festivals held on an island. Chapter 4 summarises the main findings and limitations of our project, along with prospective ideas for further investigation.

1.2 Biodesign technologies

The recent development of genomic research has led to the convergence of chemistry, engineering, nanotechnology, and informatics. Genome analysis, editing, and synthesis technologies have been used to develop increasingly complex artificial computation devices using engineered biological motifs (Manzoni, Urrios, Valazquez-Garcia, de Nadal & Posas, 2016), in addition to digital tools for acquiring, storing, distributing, and analysing genomic big data (Stephens et al., 2015). These techniques apply rational design rules to the use of living organisms in structures, objects, and tools that is often conceptualised as 'biodesign' (Myers 2012). Unlike other emerging technologies, such biodesign technologies have two specific features: (1) anthropogenic (designing nature) and (2) heritable (designing the future). Hence, biodesign technologies enable researchers to design a living system, as well as to observe how this system and its environment transform over time by analysing, editing, and (re)constituting biological materials. The results are widely applicable to medicine, industry, agriculture, and environmental science, including genetic engineering, genome editing, synthetic biology, biomimetic chemistry, and molecular robotics. As biodesign technologies blur the boundaries between the natural and artificial and cause long-term effects on entire living systems, the autonomy and irreversibility of these systems has become vital (Schmidt, 2016).

1.3 Designing (with) publics

Public engagement is a necessary part of opening up future directions of emerging technologies; however, little is known about who are the publics to be engaged (Stilgoe, Lock & Wilsdon, 2014). Designing with publics does not mean consuming pre-existing publics but rather connecting to multiple and mobile publics that temporarily emerge and assemble around shared concerns (Birkbak, Petersen & Jørgensen, 2018; Galloway, 2010). Continuous, active engagement is key to improving public understanding (and appreciation) of science and reaching an audience that may otherwise not dare to enter scientific venues. This dilemma can be solved by fostering public engagement in science outside of formal learning environments (Falk & Dierking, 2010). One possible answer is to turn to the social science understanding of mobility, which focuses on how people physically and socially shape the world through how they move and mobilise people, objects, information, and ideas (Büscher & Urry, 2009). In such an approach, human and nonhuman actors as the participants are placed on equal footing. Mobilising publics in relation to the governance of biodesign technologies can further breach the boundaries between nature and artefact and between designers and the designed. The following two chapters demonstrate how we co-created a product and project on biodesign technologies using a novel approach that applies visual thinking strategies to real-world issues via design and places them in unusual locations to attract multiple and mobile publics.

2 A mobile product

2.1 VTS as meta-design

We began our design process with meta-design. While participatory design involves users in shaping a project and ends when the product is taken into use, meta-design allows users to act as designers by anticipating or envisioning potential design to take place in use after project design. It empowers all stakeholders (including end users) to actively engage in the ongoing development of personally meaningful sociotechnical systems (Fischer & Herrmann, 2011; Ehn, 2008). In order to collaborate with general citizens as potential product users, we applied visual thinking strategies (VTS). VTS is an approach that uses discussion of artwork or visual images to encourage creative and critical thinking as well as communication and visual literacy skills (Yenawine, 2013; Moeller, Cutler, Fiedler & Weier, 2013). It invites viewers to freely share their multiple perspectives about artwork or visual images by asking three deceptively simple questions:

- What's going on in this picture?
- What do you see that makes you say that?
- What more can you find?

Although VTS has been used in the sciences (The Wild Center), it has not been previously used in bioart, which requires integration of ethical and moral discussions in bioethics and aesthetics (Vaage, 2016). Bioethics is always at risk of focusing on future ethical matters by reflecting on possible and speculative technological developments, with consequences that demand immediate attention (Nordmann & Rip, 2009). Aesthetics also has difficulty in addressing and recognising authentic issues, for which VTS requires viewers not only to provide their views on the artwork, but also to reflect and reframe their values within the social context (i.e. meta-cognitive thinking). As these interdisciplinary discussions require a certain level of critical thinking and literacy skills, it is vital not only to have a good facilitator, but also to focus VTS on an accessible, ethically ambiguous work. Moreover, viewers may find it difficult to objectivise an artwork containing overly multi-layered concepts that generate spatiotemporal transformations, presuppose specific contextual knowledge or reflect the whole project process as a piece of work (Kitano & Hara, 2017).

The bottom line is that most existing bioart works remain conceptual, ethically unambiguous and/or technology-oriented; none of them address gene drive technology and its ethical and social ramifications. This led us to produce a new mobile, tangible, and approachable piece in collaboration with designers and artists. While often used as an art education method, we applied VTS to ask viewers to consider more open-ended, value-laden, ambiguous questions such as: 'What does this image tell you about the societal implications of emerging technologies and desirable futures'?

2.2 Gene Drives Elastic Future

We named our final design product *Gene Drives Elastic Future* (2018). It consists of a lift-the-flap book on the governance of 'gene drive' technology with a mixture of photos, illustrations, manga stories, pop-ups, and layered pages. Gene drives is a biodesign technology to alter or suppress wild populations by adding, disrupting, or editing genes and propagating traits that reduce reproductive capacity (Esvelt et al., 2014).

The book is divided into three sections. The first comprises two facing pages expressing the dual nature of gene drives using intertwined and layered images of socio-biomaterial

assemblies in our daily lives: vaccinations, a doctor visiting a school, eggs, the flu virus, sneezing, a pedestrian crossing, a chicken, traveling to a tropical region, insect bites, and a mosquito. In this section, viewers are asked to contemplate the following question: ‘Are daily life and biotechnology related’? (Figure 1)

Figure 1. Section 1 of Gene Drives Elastic Future

The second section refers to the current governance of biodesign technologies in order to discuss the consequences of gene drives for future societies. This section includes a small, manga-style book that describes how gene drives propagate a specific suite of genes throughout a population and how this technology could potentially wipe out mosquitoes that transmit malaria, dengue or zika to improve public health. As the leading question—‘What are the light and dark sides of biotechnology’?—suggests, the manga story suddenly stops by inferring the negative aspects of this technology. The manga book is followed by drawings of two possible future worlds: what may happen if gene drives are used and not used, and the resulting vivid interactions between humans, machines, plants, and animals. Again, both positive and negative consequences are suggested in the drawings (Figure 2).

Figure 2. Two possible future worlds shown in Section 2

The book ends with two pages, separated by tracing paper, which show two different research spaces: (1) academic researchers in an advanced lab and (2) amateur citizen scientists in a domestic kitchen (Figure 3). The amateur citizen scientists with biodesign technologies, called do-it-yourself (DIY) biologists or biohackers, mostly take interdisciplinary, open, and not-for-profit approaches whilst developing cost-effective tools and equipment and working for democratisation of self-empowerment. Their activities also raise a wide variety of issues concerning research and product safety, public health and environment, biosecurity, and ethical and social implications of emerging technologies

(Seyfried, Pei & Schmidt, 2014). Inspired by transhumanism, which advocates the enhancement of human body and intelligence by technology, the motivations of biohackers include cybernetic exploration, personal data acquisition, and advocating for privacy rights and open-source medicine (Yetisen, 2018).

Figure 3. Biohackers in a kitchen in Section 2

The third section also contains two facing pages but includes pop-ups that appear when opening the pages. This section focuses on two questions: ‘Are gene drives my business?’ and ‘How are gene drives related to me?’ Readers are asked to make this issue their own and behave as active actors, rather than passive viewers in the current context of sociotechnical governance. The pop-ups three-dimensionally arrange different images of humans and their associations: experts on an advisory committee, neighbours gossiping, academic researchers, biohackers, a mother caring for her child, a rough-and-tumble boy, a bemused girl, a worried couch potato, a chronically ill patient, and a disappointed traveller (Figure 4). In the governance of biodesign technologies, neighbours, and biohackers may become more of political actors, corresponding to experts and academic researchers in conventional governance. Mothers and patients who prevent infectious diseases would also be affected by the development of gene drives. Even bystanders could be empowered by changing their awareness, understanding, and behaviour.

Figure 4. Pop-ups in Section 3

An illustrator worked under the direction of a product designer, who added photos and paper pop-ups and compiled them into a book. From the very beginning, they closely collaborated with different researchers in art education, epidemiology, biosecurity, bioethics, and science policy. The design was modified several times during production. An epidemiologist pointed out that adult anopheles mosquitos always rest with their abdomens sticking up in the air, causing us to redraw a mosquito in the second section's manga book. We also updated the portrayals of stereotypical, obsolete laboratory equipment, supplies, and instruments after receiving suggestions from a university researcher and visiting his lab.

After the product was finalised, we organised a six-hour VTS workshop at the Kyoto University of Art and Design (KUAD) in June 2018, during which we invited five citizens to participate (Figure 5). As part of the meta-design and project design steps, we then reflected on the workshop's outcome and developed additional ideas on how to use this design product. Two months later, we visited Sado Island in Niigata Prefecture, Japan to test the product.

Figure 5. VTS workshop at KUAD

3 A mobile project

3.1 Art festivals and islands

The Earth Celebration (EC) is a summer festival that has been produced by the Kodō Taiko Performing Arts Ensemble since 1988. Internationally renowned for its performances of a broad range of Japanese percussion instruments, the festival showcases outdoor concerts, workshops, and the Harbour Market at Ogi Harbour. It is held at the southern part of Sado Island—the sixth largest island of Japan just off the city of Niigata on the Japan Sea Coast. In 2018, the Sado Island Galaxy Art Festival (SIGAF) grew out of artistic sensitivity and cultural tourism on the island that developed following the EC. At these art festivals, we saw an ideal public space to attract those not necessarily interested in science and technology (cf. Bultitude & Sardo, 2012). Therefore, via site visits and remote exchanges, we built rapport with both the SIGAF executive committee and the EC general producer, eventually securing workshop space at the Harbour Market during the EC and an event venue at the i-Port Sado Complex during the SIGAF.

These art festivals were especially appropriate venues for our project because of their location on Sado Island. Our project name, ISLE, is not only a backwards version of ELSI,

but also reflects the vital role of islands as spaces for public engagement and mobility. Islands exist in a state of tension between openness (migration and mobility) and closure (insularity and isolation), which is reflected in islanders' identity and way of life (Baldacchino, 2004). In addition, discussions regarding colonialism and sustainability are necessary to improve islanders' lives, as well as to safeguard their cultures and environments (Grydehøj, 2017). Such tensions are apparent on Sado Island. For example, the Sado Gold Mine was Japan's largest gold mine and operated from 1601 until 1989. Another instance is the Kitazawa Flotation Plant, a gigantic industrial heritage site that was once the largest ore beneficiation plant in East Asia. Now serving as tourist attractions, these places commemorate how workers suffered under poor working conditions due to government and industry pressures. Although the art festivals do not explicitly focus on this dark legacy, most festival participants (tourists as well as local residents) were well-aware of these locations. Both the art festivals and Sado island thus sharpened a 'sense of place' in the dynamics of human-environment interactions among participants (Haywood, 2014).

3.2 Mobile citizen science

However attractive our product may seem, it is quite hard to engage people who otherwise may not think and talk about science and ethics in unusual locations, such as art festivals and islands. Our project thus needed a priming event and agent to connect keen public interest in the arts and tourism to people's active engagement with our product. The agent is the Science Communication Research Institute (SCRI), based in the city of Yokohama. Together, we shared a tented booth at the Harbour Market (17–18 August 2018). There, the SCRI sold the 'L-eye', a mobile microscope that attaches to smartphone cameras and can take photos and movies of minerals and micro-organisms. To promote the L-eye, the SCRI created a 50 × 50 cm^2 exhibition space called 'Go-Go-Museums', where visitors could experience micro-worlds in an easy and enjoyable way. Volunteering high school students were able to combine the L-eye with a citizen science app called 'iNaturalist'. This app was launched in 2008 to serve a global community, and to aid in the observation and identification of natural phenomena, allowing users to explore, observe, and discover the natural world by taking pictures of naturally occurring organisms, and uploading the images to a global community of naturalists who crowdsource to identify them (Nugent, 2018).

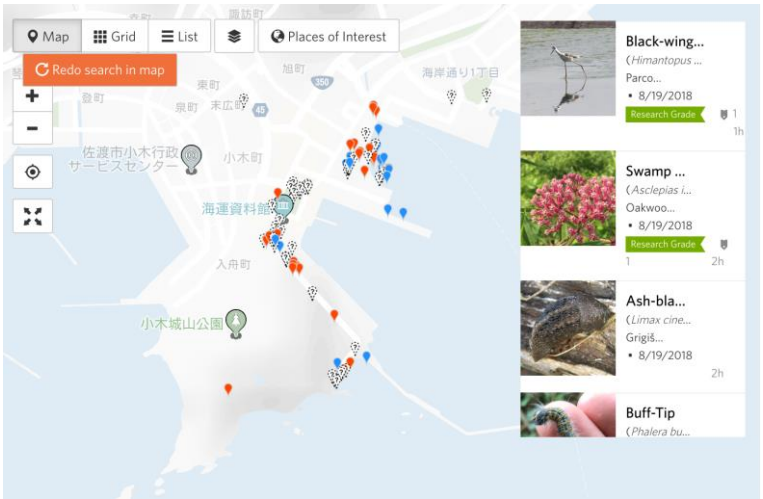

Figure 6. iNaturalist location mapping during the EC festival

These mobile tools take science out of the laboratory, opening the field to the public and galvanising people and things as mobile publics. The high school participants took pictures of organisms around Ogi Harbour and uploaded them to iNaturalist (Figure 6). Thus, they had some opportunities to reconstruct the meaning of nature and science around them.

3.3 Pop-up talks

Through the SCRI's priming event with their mobile tools, our project members chatted with visitors and showed them how to use the pop-up book. Although a few people showed some interest and gave us useful comments, more intensive discussion was needed. As a prototype for a later public workshop, we then organised a casual, brief open-air interactive session of VTS on *Gene Drives Elastic Future* at a park in the Harbour Market close to the EC venue.

The participants were seven local volunteer high school students who helped to manage the EC festival and joined in the iNaturalist location mapping. Four took part in two 30-minute sessions in the morning, and three in the afternoon on 18 August. Informed consent was obtained from all respondents to collect their data. First, we asked them to flip through the book individually for several minutes; we initially provided them with no information or instruction about our identity, project or product. We then facilitated a group discussion where they guessed what the product was saying, why we made it, and their impressions. General impressions focused on socioecological vulnerability to emerging biotechnologies, but one participant took away a message regarding the relationships between humans, animals, and artefacts. Going beyond contrasting technology as the subject with society/environment as the object, she seemed to achieve a sense of the sociomaterial assemblies as publics. Participants' final comments showed their willingness to realise and commit to the worlds they did not know, to critically and reflexively examine their daily lives and social change, and to clarify and share a desirable future. Because they had little knowledge of the development and governance of genetic technologies and identified potential issues on their own, this participatory exercise can be considered as having a new type of participatory design that is not technology-driven or issue-oriented but rather involves the co-designing—or at least the co-wondering—of sociotechnical worlds. In this case, gene drive technologies, sustainability, and public health concerns triggered public debate on a desirable future.

3.4 Public workshop

On 19 August 2018, we held a 1.5-hour public workshop on *Gene Drives Elastic Future* at the i-Port Sado Complex. An artist-scientist delivered a talk on the interactions between life science and art, and an ethicist gave a presentation on the ethical implications of gene drives. In between the two speakers, we organised group VTS discussions. Around half of the 15 participants were local Sado residents, including city councilors, an amateur artist, a schoolteacher, and a high school student. The others were project members and experts in science, ethics, policy, education and/or communication. Informed consent was obtained from all participants to gather the data.

We asked them three questions: (1) 'What is this book?' (2) 'Do you like the worlds illustrated in the second section?' and (3) 'What do you think the third section represents?' Responses to the first question include 'polemic', 'challenging', 'an apparent picture book', 'a sophisticated manga study book', 'suggesting invisible risks', 'connecting daily life and lab', 'different ideas on arts or life can be drawn by different viewers', and 'half of the book

addresses problems but the other half explores solutions via the two possible future worlds' (see Figure 2). The second question does not conform to the typical VTS framework, but was intended to examine viewers' own values. Most of the respondents were unable to judge which world they wish to live in because they found the negative, positive, and ambiguous aspects of both worlds. The discussions among one group then moved on to alternative precautions against mosquito-borne diseases. At the end of the workshop, we asked them to write down what they had learned during the talk, and then to share what they had written with others. Their final statements included the importance of talking about unknowns, increased curiosity regarding the term 'kitchen biology', and the value of such a fundamental discussion (Figure 7).

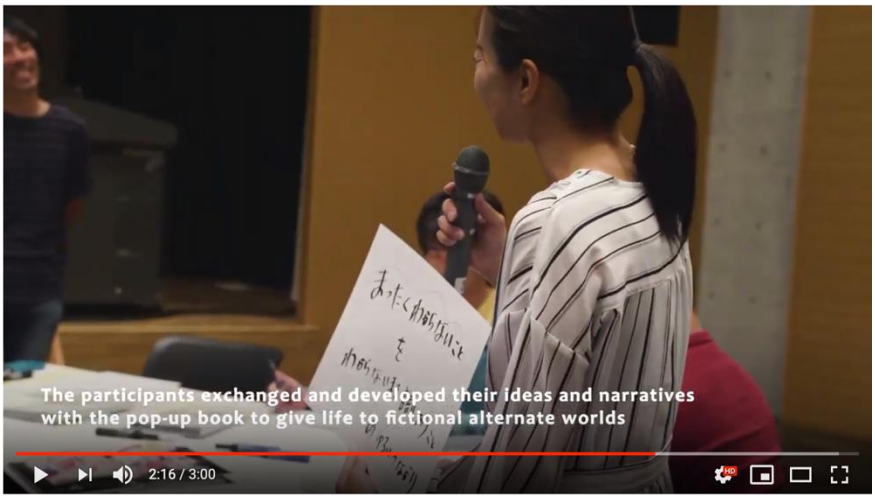

Figure 7. Public workshop at the i-Port Sado Complex. Source: https://youtu.be/TP7jIsarl-Q

In addition to posters and flyers distributed at the art festivals, Ryōtsu Ferry Terminal and a café, several priming events were conducted for this workshop. At the same venue, there was a special exhibit featuring panels of drawings from *Watashi Wa Shingo* (My Name is Shingo), an internationally acclaimed manga series by author Kazuo Umezu, published between 1982 and 1986. This science fiction story centres around a hand-shaped robot with human emotions that believes an elementary school-aged boy and girl are its parents. Sado Island serves as one of the locales in the story (Figure 8).

Figure 8. Panel exhibition of 'Watashi Wa Shingo'. Source: Hara (2018)

As the exhibit was organised as part of the SIGAF and we collaborated with this festival, the exhibit and our organised events resonated with the audience members. Our event was titled ‘Animals in Sado, or a Super Lifeform’. Next to the exhibition space, the SCRI, in collaboration with the Sado Institute of Living Creatures (a civil society organisation for environmental education and communication), conducted another L-eye workshop through which participants jointly observed, photographed, and made a visual dictionary of microbes living in nearby paddy fields. The SIGAF and SCRI events were publicised together on 31 July through Dommune, a live streaming channel for broadcasting various cutting-edge aspects of culture. All of these events and materials served as publics as well as enablers for different people to participate in the workshop and project.

After the art festivals, we compiled both the project and product processes as open-access videos to promote our work (Figure 6). One of our members also presented public engagement activities on the project at the Biological Weapons Convention (BWC) Meeting of Experts in August 2018. These materials became independent actors for attracting those who may be interested in our work.

4 Conclusions and future work

As biodesign technologies transcend the boundaries between the natural and the artificial, and meta-design empowers all stakeholders to be actively engaged in the ongoing development of sociotechnical systems, designing the governance of biodesign technologies becomes anticipatory, reflexive, and analytic with multiple and mobile publics. Our designed product on the governance of gene drives was co-created by artists/designers and researchers from various disciplines. The product, with the help of VTS as meta-design, enables viewers to consider and discuss how socio-biomaterial assemblies around gene drive technology are disseminated in our daily lives, and how they are governed and related to each viewer. Our project selected two art festivals held on an island as unusual event venues for VTS, mobilising researchers, art festival organisers, science/environmental communication organisations, volunteer high school students and local residents, as well as our designed product, naturally occurring organisms, citizen science tools and data, events, exhibits and festivals, and the culture and environment of Sado Island. Considering the future governance of biodesign technologies, this heuristic mobilisation blurs the boundaries between nature and artefact and between designers and the designed.

We also faced some limitations. First, despite the help of festival organisers and science/environmental communicators, we attracted and involved a limited number of tourists and festival participants due to the short lead time. Second, both the pop-up talks and the public workshop were rather conventional, immobile settings in which participants were likely to try and give the ‘right’ and polite responses. Third, we have been struggling to find more effective channels through which key stakeholders can communicate, discuss, and decide with broader publics, as well as evaluate the effectiveness of public engagement.

As the next step, we will visit Teshima Island during Setouchi Triennale 2019, a contemporary art festival, and develop ways to identify participants’ views on nature and the future based on our survey analysis of ambiguous public views toward synthetic biology and gene editing. To accomplish this, we will not only organise a VTS workshop, but also apply walking methods for tourists and local residents with audio transcription, photos, and location mapping tools (Macpherson, 2016). Participants will then be able to locate the product and

the project more naturally during the course of their visit to or living on the island, and during the art festival. Government policymakers and journalists are also invited to contribute to the development of a new policy framework for biodesign technologies. Considering that all of the sociomaterial assemblies presented on the island, the art festival, and the workshops are represented in the product, the (social) media tools, and the project are more likely to be mobilised to form publics beyond people.

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Review of Theory, Key Technologies of Value Creation in Product Design

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Value creation is an important part of product design. Within the context of service-oriented manufacturing transformation from Goods-dominant Logic (GDL) to Service-dominant Logic (SDL) paradigm, this paper collects and analyses the relevant literatures of product value creation, and points out the focus and trends of product value creation. Those are the transformations: Ⅰ.From the emphasis on the material value on the product side to the spiritual value on the customer side; II. The shift from the value of use and the value of the economy to *Kansei* value of added value; III. From consideration of value creation of single product under the customer perspective to comprehensive consideration of relationship and structure of production, distribution, transfer and use of product value among the value chain, value network including product stakeholders; IV. From static value creation to dynamic value co-creation of product in time dimension. Furthermore, the study concretely analyses the research progress and trends of theory, technologies of value creation in product design by the Quantitative Type III and Cluster analysis.

Keywords: Service Product Design ; Value creation ; Kansei value ; Quantitative Type III ; Cluster analysis

1 Introduction

In the era of Industry 4.0, intelligent technology systems have become a new kinetic energy to guide economic development. The continuous innovation of technologies such as mobile Internet, Internet of Things, and people's networking is driving the development of industrial design. The design paradigm has undergone a transition from "Product-centred · Economic priority" to "User-centred · Life priority". The focus of product innovation shifts from the usability design of mass manufacturing products to the emotional and experiential design of personalized products and services. In the context of improving quality and efficiency in manufacturing, and transforming and upgrading services, creating high added value has become the key for enterprises to win core competitiveness in the fierce market competition. The Japanese industry calls this high added value as *Kansei* value, which is the fourth value axis in addition to high performance, high reliability and low price (Ministry of Economy, Trade and Industry, 2007). *Kansei* value creation is the core of service product design (Dongxiao Chu, 2014). Systematic research and combing the value creation theory in the

design of existing service products is an important step for enterprises to create high added value and enhance the core competitiveness of the product market.

2 Service product value creation

2.1 The value of the service product

The word Value first appeared in the field of economics. In the 17th century, British economist William Petty first proposed the theory of labour-determined value, that is, the labour time spent on producing goods determines the value of goods. British economist Nicholas Barbon put forward the theory of utility value, emphasizing that value comes from the utility of the goods and focuses on the usefulness of the goods. In 1750, Italian economist Ferdinand Galliani proposed that scarcity can increase utility, and his research extended from labour-determined value and utility-determined value to the extended value of marginal utility.

Under the dominant logical paradigm of artefacts, the semantic evolution of artefacts as industrial design objects has gone through three stages: " Goods →Products →Commodities ". The focus of product value research has experienced "Use value→ Exchange value →Economic value". The transfer of consumer demand for product design has undergone a three-stage transition of "Usable → Convenient → Humanized "(Dongxiao chu, Xueman Chu, & Yujie Peng, 2017).

Under the Service-Dominant Logic paradigm, the product is a service-dominant product, which is essentially a "Service Product". The connotation includes "Service" and "Product" that are created. The most important feature is to create *Kansei* value Which can bring happiness and benefit to the people (Dongxiao chu, Xueman Chu, &Yujie Peng, 2017). In design research, the value of service products can be divided into two categories: material value and spiritual value. The material value includes the use value and economic value. The economic value is essentially an exchange value; the spiritual value can also be called *Kansei* value (Dongxiao Chu, Ono Kenta, Terauchi Fumio, Walanabe Makoto, &Aoki Hiroyuki, 2010). In addition, scholar Anderson and other scholars believe that value is customer perceived utility relative to purchase price, reflected in economic, technical, service and social benefits and so on. The traditional value creation view believes that value is the objective existence of functional value, which exists in the presence of products, and enterprises can carry out unilateral production. The modern value creation view considers value as a subjective experience, a consumer's psychological activity, and product value cannot be separated from the participation and creation of consumers.

In the process of "creating goods" to "making meanings", the service products require products to pay more attention to the "meaning" on the basis of paying attention to the "production" itself, and arouse the emotional mutual feeling and association of consumers. It is the focus of service product design and development (Dongxiao chu, et al., 2017). At this point, consumers pay more attention to the emotional experience when they buy products and services. What consumers need is no longer specific products, but the utility provided by these products and services (Mont,O.,2003).The mining of value growth points of enterprises has also shifted from product to human research. The focus of product value creation also shifts to *Kansei* value creation. The emotional value (Naisbitt,J. & P. Aburdene, 1991) generated by high sentiment (Ministry of Economy, Trade and Industry, 2007) (The fourth value axis "+a" value) has made a great contribution to product value creation.

2.2 Emotion and product value

Emotion defines the core content of the experience, and leads the generation of decision-making, establishing a personal relationship between things and people. The process by which consumers consume products and services is a process of emotional experience. The generation of consumer behaviour is the decision made by the consumer through irrational decision-making and rational judgment (Damasio A R., 2015), and then subconsciously perceives the interpretation of the product's emotion and establishes a relationship with its personalized deduction (Reeves, Nass, 1996). Creating models through research on perceptual and *Kansei* value helps to capture the emotional needs of consumers in different areas. At the end of the 19th century, the psychologist William James began to study emotions. Designed for emotion, in 1962 Robert Plutchik (1962) proposed an emotional model to describe how different emotions are related. In 2000, Jordan proposed the type of user interest to describe the different types of interest values that products bring to consumers (Jordan, 2000). In 2004, Norman proposed a perceptual three-level theory (Donald A. Norman, 2004). In 2008, Demir proposed three types of reactions: automatic response, feelings generated through interaction, and relationships established in the time dimension (Erdem DEMİR, 2008). In 2012, the Japanese Association of Sensible Workers proposed a three-level theory of *Kansei* value creation (Ministry of Economy, Trade and Industry, 2007).

In industrial design, Artificial Intelligence (AI) introduced embedded technology into product design, which made the operation mode, function and usage scenario of products develop towards software operation related to the Internet of Things. Artificial Intelligence focuses on user experience in human-computer interaction (Fan, Fan, &Tian, et al., 2019). Research on human emotion or emotion generation mechanism has an effective guiding role for user experience. Artificial intelligence can be divided into human + machine + intelligence, that is, to import emotions into the machine, so that the machine can achieve the same way of thinking as human to deal with problems, and gives the same emotions to the machine. Through the emotional communication between machines (products) and people, consumers can resonate. Then the resonance triggers the spiritual value of consumers in the service experience process, and urges them to make decisions such as purchasing. David Chalmers, a philosopher and cognitive scientist, divided the problem of understanding human consciousness into "simplicity" and "difficulty". For Artificial Intelligence, the simple problem is to create a robot that can simulate human emotions. This kind of problem can be measured by the standard method of cognitive science. The difficulty is to create a robot that can feel people's emotions. This kind of problem belongs to the problem of experience. Technological innovation under the intellectualized transformation promotes *Kansei* value creation of service products.

3 Value creation theory system and application

Exploring the value growth point and development direction, researching the added value of products first needs to understand the evolution of different dominant logics of the value creation mechanism. Combined with the value model, comprehensive consideration of value to create the impact of various stakeholders on product design and value creation dimensions is an effective way to maintain or enhance products, and has important guiding significance for the future development of value creation.

3.1 Evolution of the dominant logic paradigm

First of all, to study the product value creation in service product innovation, we should understand the core ideas of different dominant logic paradigms. From the perspective of marketing, the dominant logical paradigm of value creation can be divided into the following three categories according to its different cores: from the perspective of producer providers, it can be divided into Goods-Dominant Logic and Service-Dominant Logic (Vargo & Lusch, 2004); in contrast, in the non-productive perspective, Customer-Dominant Logic and Memory-Dominant Logic (Harrington, Hammond, & Ottenbacher, et al., 2018).

In traditional manufacturing, mechanized mass manufacturing-oriented Goods-Dominant Logic (GDL) emphasizes that companies create value through products and technologies. Consumers purchase products of different categories to meet psychological needs and obtain the reputation and status of the products, while product value creation is terminated when consumers purchase (Jallat, 2004). With the transformation of manufacturing services, there has been a shift from "product-centric" to "service-centric". Under Service-Dominant Logic (SDL), product value creation is no longer limited to the manufacturing of enterprises, but more concerned with the design and service-related contacts and the establishment of multi-relationships to enhance consumers' experience in purchasing products and using them. Through the provision of production-related service systems, enterprises create co-creation with consumers (Vargo & Lusch, 2004; Vargo & Lusch, 2008) and form a systematic value network (Kothandaraman & Wilson, 2001).

From a non-productive perspective, in Customer-Dominant Logic (CDL), Anderson and others believe that value is customer perceived utility relative to purchase price, which is reflected in economic, technological, service and social benefits. Value is the psychological activity of consumers and a subjective experience. The value of products cannot be separated from the participation and creation of consumers. In Memory-Dominant Logic (MDL), enterprises not only pay attention to how service experience affects consumers' satisfaction and loyalty, but also pay more attention to how to create value according to the uniqueness and individuality of experience to promote consumers to produce sustainable memories. Good memory, as a consumer's consumption decision transformed from experience, can bring potential competitive advantages to enterprises (Harrington, Hammond, & Ottenbacher, et al., 2018).

The development of the dominant logic paradigm has gone through four stages: from Goods-Dominant to Service-Dominant to Customer-Dominant to Memory-Dominant. From a productive enterprise perspective, it is not just the value-added creation of products, but how the utility provided by these products and services creates value with consumers and focuses on the importance of collaborative innovation (Rich, 1999).

3.2 From the traditional value axis (+a) to the fourth value axis

In the field of product design, the traditional value axis focuses on creating value from the enterprise, and consumer purchasing decisions result from an assessment of the weight of the product's function and price. For consumer groups with different abilities, on the basis of satisfying the function, whether the price meets the expectations of consumers becomes the key to decision-making. Service-oriented products, powerful features and low prices can no longer meet the needs of consumers. Different from the (+a) fourth value axis of the traditional value axis, Kansei value is incorporated into the core of value creation, focusing on creating emotional resonance. Enterprises create their Kansei value by providing quality service by telling story and making meaning (Dongxiao Chu, 2017) to attract consumers, and

through consumer feedback on products, decide whether to enhance the corresponding emotional attributes, such as relaxation, security, and friendliness. The culture, technology, service, and emotion that the enterprise gives to the product will directly affect the consumer's evaluation of the product. Consumer feedback on the product will also become an important basis for product iteration improvement.

3.3 Value models

Currently, in the field of economic management, based on the dominant logic paradigm, in the perspective of producers: Michael E. Porter proposed the Value Chain in the book *Competitive Strategy* in 1980. It is used to explain the value activities carried out by the company in the whole life cycle of the product. It mainly focuses on the value activities in the chain that can bring economic benefits to the enterprise, and brings strategic advantages to the enterprises in the face of competition. In the non-productive perspective: Adrian Slywotzky proposed the Value Network in the book *Profit Zone*, emphasizing that companies should break the traditional value creation logic and benefit relevant people are integrated into the value chain, paying attention to user needs and user preferences in order to face market-level competition, and then achieve a win-win situation.

Secondly, in the field of service product design, it is helpful to understand the key points of service product value creation by combing the core viewpoints of existing scholars and services and the theoretical models related to service product value creation. From the perspective of the service process, Tomiyama (2001) pointed out that service is an activity that changes the state of the recipient; Yoshikawa Hiroyuki (2008) believes that service is the result of a behavioural output, and this behaviour comes from the engine Feedback from the output of the next; From the perspective of service science, IBM research departments pay more attention to the interactions generated by the recipients in the service process. At the same time, the "IHIP" model of services (Naito, 2009) indicates that the service itself has intangibility, heterogeneity, inseparability and perishability. These abstract features of the service itself make the service design activities more concerned with the maintenance of intangible relationship elements and co-creation through such services. Service-related models In addition to the IHIP model, Ueda, Takenaka, Fujita (2008) pay attention to the interaction between artefacts, people and the environment, nature and social environment, and propose the Ueda model based on the content created by the service value: Type I providing values, Type II adaptive values and Type III co-creative values. Shimomura,et al (2005) pay attention to the content of the service, the channel, and the state change after the recipient receives the service. It believes that the value of the service can be assessed by the state change generated by the recipient after experiencing the service, and subjectively based on the service. The characteristics propose "flow model", "scope model" and "view model", collectively referred to as Shimomura model (Shimomura,et al, 2003). Based on the above service value creation model, it can be seen that the service value creation focuses on the interaction between "goods + people + market + environment" (Dongxiao Chu, 2014), and on this basis, the development direction of product value creation is sorted out by studying relevant literatures of scholars.

4 Research hot-spots and development trends

4.1 Analysis methods and processes

Through the integration of 50 research papers related to value creation, 37 keywords were extracted, and the research status of value creation was analysed and summarized by using

quantitative Type III and cluster analysis methods. According to the results of cluster analysis, 37 keywords are classified into five groups of G1-G5 (Fig.1), and then these keywords are marked by spatial points to generate 1-2 axis distribution by visual method (Fig.2).

G1 mainly studies the value creation of the static value dimension of products from the perspective of human-computer interaction. Research on product form image and symbolic semantics from a product perspective. Using product family design (Bin Zhu, Pingyu Jiang & Jianning Su, 2004) and sensibility engineering (Shijian Luo & Yunhe Pan, 2007; Junsheng Kuang & Pingyu Jiang, 2007) and other methods, pay attention to the relationship between product shape and user demand preferences, optimize product design, mostly used in CAID field (Xiaopeng Hou, Suihuai Yu & Wen Zhao, 2008). Focusing on product aesthetics and emotional experiences from a user perspective, the goal is to create value through product + user (Mcdonagh, Bruseberg , &Haslam, 2002). Based on the user's cognition, the main focus is on how to create product *Kansei* value by researching the symbolic semantics of products and realize value growth; and through ergonomics, pay attention to the aesthetic problems of products under visual perception (Mcdonagh, Bruseberg , &Haslam, 2002).

G2 is a study of product dynamic value creation from a time perspective, considering *Kansei* value creation and change of time factors. Mainly concerned with value transfer and value evolution (Xiaopeng Hu, 2004), through product life cycle management and evaluation, timeline design and other methods to study the evolution and transfer of product value in the time dimension (KamiyaK, Kito, Alvarez, et al., 2014). G3 is a technology and method perspective, focusing on the sustainable design of products, focusing on green sustainable value creation on the product life cycle based on the G2 time dimension (Jing Li, Fangyi Li, Lirong Zhou, Xingshuo Xu & Qiang Meng, 2016), and through colour image research(Man DING, Wei SUN, Jiang XU, & Xu ZHANG, 2011), emotional calculation (Kun Huang, 2007), BP neural network(Lai, Lin,& Yeh,2005; Lai, Lin,& Yeh,2006), sensitivity analysis (Jing Li, Fangyi Li, Lirong Zhou, Xingshuo Xu & Qiang Meng, 2016) and other methods to integrate user perception into product design.

Both G4 and G5 conduct research on the value creation of service products from the perspective of management and marketing. Among them, G4 mainly studies *Kansei* value based on customer relationship from the perspective of management and marketing (Hald, Cordón, & Vollmann, 2009; Smals & Smits, 2012); from the perspective of management and strategy, studies the creation of *Kansei* value under new technology (Rayna & Striukova, 2016). G5 focuses on service quality and consumer demand. From the perspective of consumer behaviour, we mainly focus on marketing and value creation based on value co-creation (VCC) (Yi, & Gong, 2013). Using QFD and other methods, focusing on the key demand of consumer satisfaction, from the perspective of service and quality, we study the problem of *Kansei* value creation such as perceptual quality and quality characteristics (Shijian Luo & Shangshang Zhu, 2005). And from the cognitive level to face the invisible needs of consumers to explore, to optimize the quality of service. Enhance consumer satisfaction and achieve product value creation through the joint efforts of culture, service and quality.

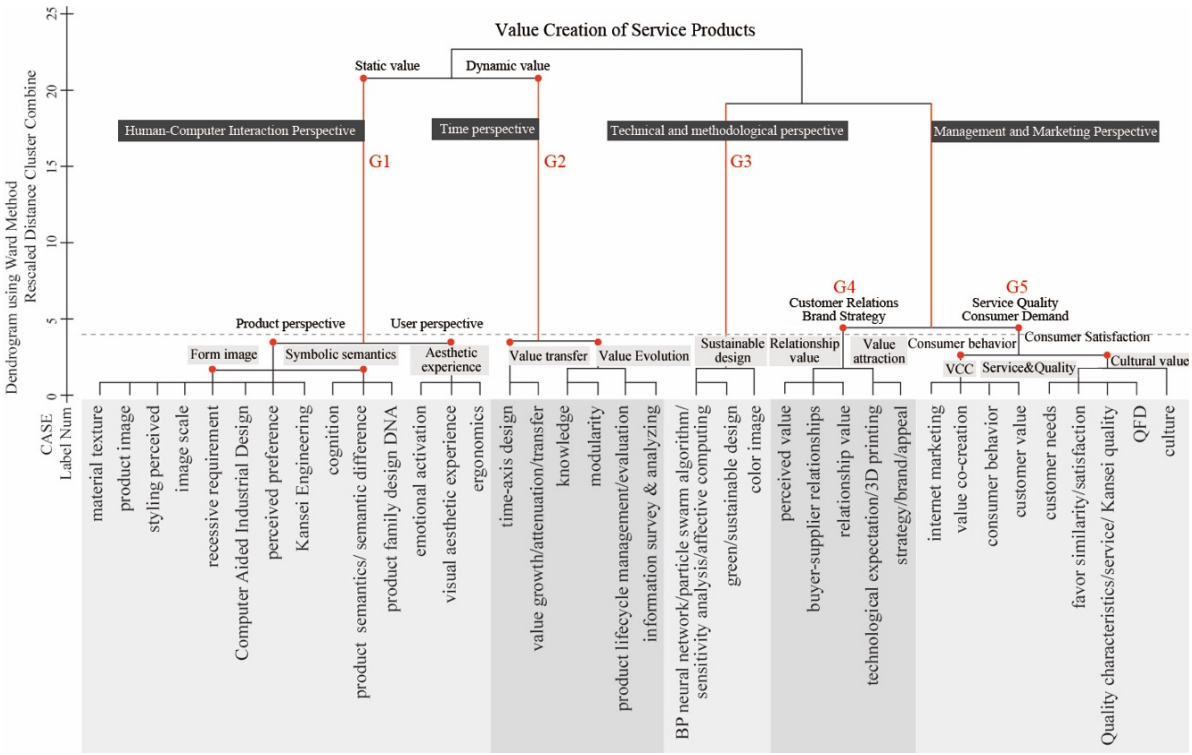

Figure 1. Keyword Hierarchical Clustering Analysis Diagram.

4.2 Analysis results

From Fig.2 (1-2 axis distribution map), we can see the related technologies, hot-spots and development trends of value creation research. At present, the value creation of service products mainly focuses on human-computer interaction (G1), time (G2), technology and method (G3), management and marketing (G4, G5). Among them, human-computer interaction and management and marketing focus on the research applications of *Kansei* value creation, service quality, brand strategy and consumer demand. At the same time, based on the value evolution, value transfer and product life cycle management evaluation, the time factor is included in the service product value research, and *Kansei* value creation and change research considering the time factor is also an important development direction for the service product value creation in the future.

Based on the background, the results of the cluster analysis based on Fig.1 and Fig.2 can lead to the following four changes in the value creation research in product design:

1 From the emphasis on the material value on the product side to the spiritual value on the customer side (Dongxiao Chu, Ono Kenta, Terauchi Fumio, Walanabe Makoto, &Aoki Hiroyuki, 2010). Focusing on products, G1 studies the contribution of product design to product material value creation by focusing on material texture, modelling characteristics, symbolic semantics, ergonomics, and visual aesthetics. Furthermore, by focusing on the user's cognitive scale and the continuity of product DNA design, we pay attention to the semantic difference of products, and based on user cognition and image scale, we study the contribution of product sensibility image to value creation. Focusing on consumer behaviour, consumer potential needs, satisfaction, and social networks, G5 focuses on enhancing the spiritual value of products and achieving value creation. From product-centric to consumer-centric, the focus of product design has changed.

2 The shift from the value of use and the value of the economy to *Kansei* value of added value. Based on technology-driven design and oriented towards sustainable design goals,

G3 focuses on the application of *Kansei* value creation methods. Combining G1 and G5 research on product image and user cognition and consumer demand, through emotional calculation and perceptual engineering, it emphasizes the importance of product *Kansei* value to contribute to product value creation.

3 The value creation of individual products from the perspective of customers to the comprehensive consideration of the value chain of product stakeholders, the transformation of the value production, distribution, transfer and use of value networks. G3 and G4 are distributed in the position where the first, second and third quadrants are close to the origin in Fig.2, comprehensive technical methods and brand strategy management, comprehensively study the contribution of multi-dimensional factors to value creation. G4 has two subsets, one that reflects research expectations, attractiveness, and the contribution of the buying and selling relationship to the value of the product relationship. Second: reflect the leading role of technology in brand strategy. The G3 and G4 regions focus on external factors such as social background, strategic relationship, and development goals for products. On the basis of G5, we study the contribution of various factors to product value creation in the context of complex extension.

4 Complex multi-dimensional changes such as the transition from static value to dynamic time dimension value creation. G1 and G2 are distributed in the first quadrant partially, which focuses on the study of *Kansei* value of service products. The emotions are studied through factors such as colour, material, modelling, image, semantic symbols and other factors. Incorporate service products. Most of G2 is distributed in the second quadrant, which focuses on the study of the dynamic value of service products in a comprehensive context. Combined with (3) simultaneous inclusion of time factors, through the timeline design, product life cycle and other design methods to study the multi-dimensional changes in value creation in the context of time dimension.

From the keywords distribution of Fig.2, the value creation of service products has experienced the development from product to user, from material to spiritual, from single to system, from static to dynamic. Among them, the study of the creation and change of *Kansei* value considering the time factor (Matsuoka Yoshiyuki, 2009) will be the focus of research on the future development of service products.

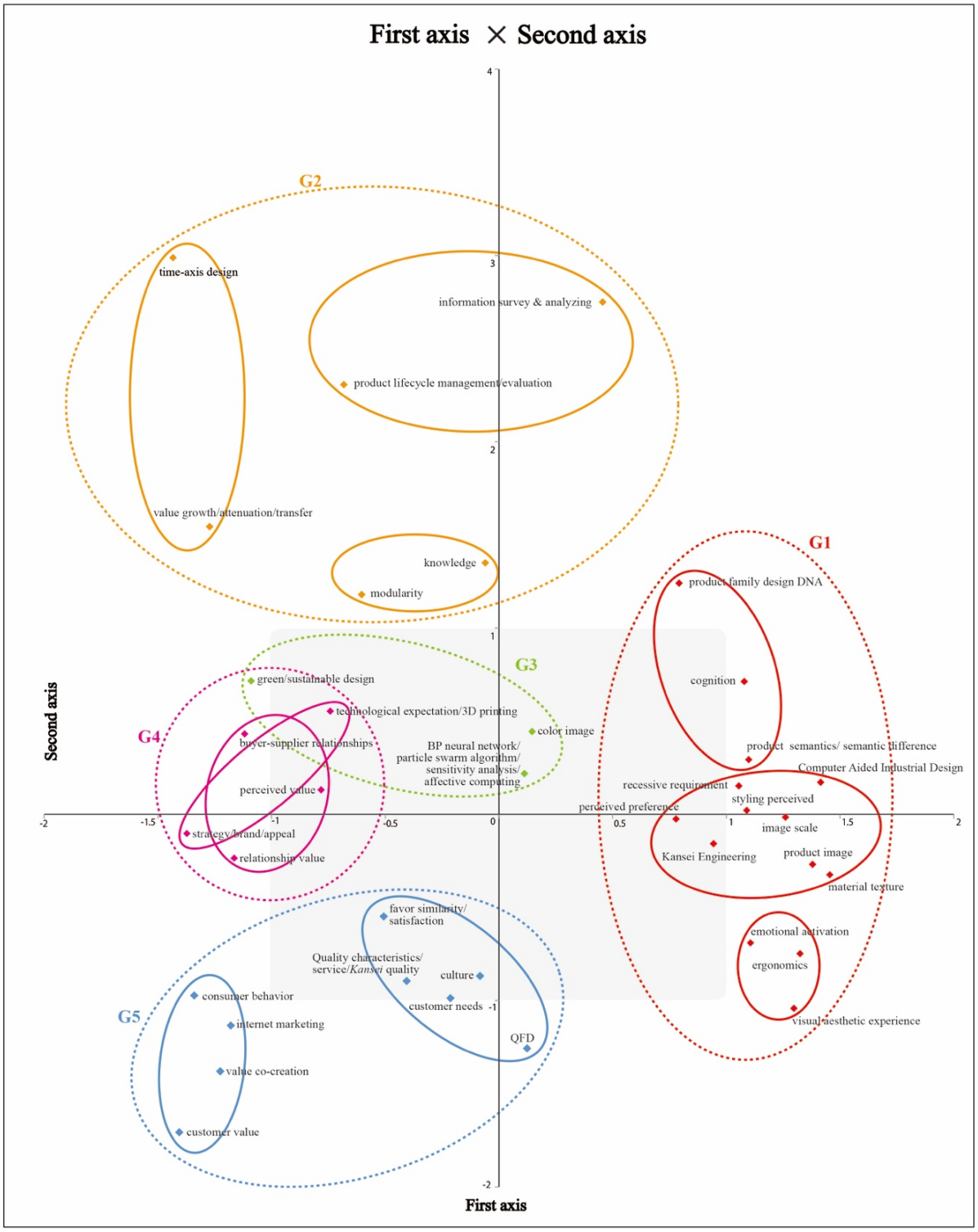

Figure 2. Keyword Scatter Distribution Map (1-2 Axis).

5 Conclusion

This paper studies the value creation of service products, and concludes that the value creation of service products has changed in four directions through quantitative research methods such as cluster analysis. The transformations are as follows. From the emphasis on the material value on the product side to the spiritual value on the customer side; Ⅱ. The shift from the value of use and the value of the economy to *Kansei* value of added value; Ⅲ.

From consideration of value creation of single product under the customer perspective to comprehensive consideration of relationship and structure of production, distribution, transfer and use of product value among the value chain, value network including product stakeholders; Ⅳ. From static value creation to dynamic value co-creation of product in time dimension. Among them, it is found that the value creation of service products mainly focuses on the aspects of cognition, perception preferences, user needs and so on from the user perspective, and from the product perspective mainly focuses on the aspects of symbolic semantics and morphological images and so on. And then, combining the technical analysis methods (such as neural network, sensitivity analysis) and market management and marketing, it shows the trend of developing from static to dynamic research on *Kansei* value creation. For designers or design researchers, it is necessary to further study the creation of *Kansei* value in dynamic time dimension with the combination of new technology and multi-disciplinary domain knowledge. This is also the next step of this study.

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The Value of Design in UK FMCG Packaging Development: An Industry Case Study Exploring Practitioner Design Practice Rationale & Decision-Making

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Recognising the value design offers has been of great importance for the effective development and launch of Fast-Moving Consumer Goods (FMCG). Packaging design is acknowledged as a significant success factor in New Product Development (NPD) for the FMCG industry to help provide clear product differentiation and competitive advantage in saturated and complex markets. The search for approaches to maintain or improve market share has driven the field of consumer research over the last few decades. The potential to influence consumer perception of a product through visual design is well documented in the literature. Packaging design relies on effective management of symbolic, semantic, aesthetic and visual information elements. Stakeholders have been increasingly demanding that design practitioners provide a clear rationale and accountability for their design proposals in this risk-averse industry. However, limited research has been produced to address how packaging design and development is managed; and, how design practitioners rationalise and validate their design decision-making. The authors' look to address this through the study of design practitioners in 'real-world' FMCG design practice. A case study is presented with a UK company involved in the design and manufacture of food and beverage packaging for suppliers, retailers and brands in the UK FMCG market. The research aims to identify preliminary insights and a narrative into the factors affecting practitioner rationale, decision-making and explore future research. The study triangulates evidesnce from interviews, participant observation, direct observation and document analysis to identify influences through a convergence of findings. Nine preliminary influences are recognised that appear to affect practitioner rationale and decision-making.

Keywords: FMCG; New Product Development; Design Management; Packaging; Design Decision-Making

1 Introduction

Design is often viewed from a business perspective as *"nice to have"* but non-essential for business performance (Bruce & Daly, 2007). More specifically, packaging design development is considered a risky and ad-hoc activity and concerns over brand damage or falling sales often lead to minor, superficial packaging changes. Design firms have been said to push adoption of new packaging innovations as suppliers, retailers and brands have been criticised for having a short-sighted view of packaging and its design, thus not exploiting its full potential in the new product development (NPD) process (Simms & Trott, 2014a, 2014b). Retailers and brands are increasingly expecting design practitioners to provide clear accountability and understanding of design impact (Young, 2002). However, from a management perspective the current activities of packaging development within the UK has been labelled as *"dysfunctional"* in its nature (Simms & Trott, 2014b). Suggestions have been made that packaging design practitioners rely greatly on their rule of thumb, professional connoisseurship and tacit knowledge in design decision-making (Johnson, Torrens, & Storer, 2019). This suggests that a degree of guesswork is utilised in packaging design concept development (Barnes et al., 2008; Ryynänen & Hakatie, 2013).To understand, reinforce and exploit the value packaging design can offer the FMCG industry, and more specifically that to new product development, practitioners need to be able to confidently and coherently express their rationale to stakeholders (McNiff & Whitehead, 2011). This paper explores the current state of design practitioner rationale and decision-making within the context of concept generation and selection for FMCG packaging. Focus is paid to the development of robust methods to investigate 'real-world' research of FMCG design practitioners to understand concept rationale and decision-making.

2 Literature Review

2.1 The Value of Design in FMCG New Product Development

Design is considered to be a substantial success factor in NPD within the FMCG industry (Wansink & Huffman, 2001). NPD is considered a risky activity (Ryynänen & Hakatie, 2014); companies can become reluctant to invest in design resources and can become a marginalised activity (Bruce & Daly, 2007 p.931). Implemented correctly, design can act as a strategic tool to add value to provide competitive advantage and aiding distinction in saturated markets (Rundh, 2009; Vazquez et al., 2003). Approximately 85% of FMCGs are selected at the point of purchase (Clement et al., 2015; Urbany et al., 1996; Stahlberg and Maila, 2012). The impact product appearance has on consumer decision making is clear (Bloch, 1995; Crilly et al., 2004). Exploiting visual packaging attributes to improve differentiation, communication and remains a useful marketing strategy (Rettie & Brewer, 2000; Underwood & Klein, 2002; Young, 2004). However, the value of design in FMCG is often neglected, and sometimes left until the later stages of NPD (Francis et al., 2008). In the distribution of an organisation's resources, packaging is often considered an unnecessary cost (Bruce & Daly, 2007; Chan, Chan, & Choy, 2006; Ryynänen & Hakatie, 2013; Simms & Trott, 2010). It is estimated that 70% to 95% of product launches fail at market each year (Spence, 2016); thus, visual design attributes can be considered one of the most crucial factors contributing to the success rate with many FMCG failures being accredited to poor package decision-making (Rudder et al., 2001; Spence, 2016).

2.2 Understanding the Creative Design Process

There is an assortment of models that help describe the design process, aiming to assist in the optimum application of design at various stages of NPD. Process models are an essential part of design methodologies. Being able to understand the processes that lead to successful designs is of great interest to commercial organisations (Gericke & Blessing, 2011). Many attempts to *"formalise and describe" the* design process have been made by constructing these models (Howard et al., 2008). Process models are particularly useful in aiding non-experts, novices, semi-experts and managers understand the design process (Bobbe, Krzywinski, & Woelfel, 2016). Within a UK context, BS7000-1 provides a generic staged gateway guide to design innovation and monitor of work via formal reviews (British Standards Institution, 2008). Gericke & Blessing (2011; 2012) present an analysis of design process models across disciplines to provide a holistic interpretation. The consensus gained was that design process models across multiple design disciplines contain general core stages in a *"stepwise, iterative process"*. Clarkson and Eckert (2005) suggest that *"all design processes are different",* but the processes across different design disciplines contains some similarities. The authors share similar beliefs of a more *"procedural approach"* which, in theory, can be suitable for designers across disciplines to be used as support (Gericke & Blessing, 2011). Gericke and Blessing (2012) provide an eight-stage generic design process which has been adopted for the purpose of this study (Figure 1), expanding on the work of Howard et al. (2008 p.163).

Figure 1. Adopted Generic Staged Design Process Model from Gericke & Blessing (2012)

2.3 Concept Development & Selection

A *'concept'* can be defined as "*a general idea or notion that corresponds to some class of entities and that consists of the characteristic or essential features of the class"* (Collins English Dictionary, 2018). A *'product concept'* in this context is a *"description of the form, function and features of a product";* and, the concept development stage is where the target market is identified, product concepts are created and then evaluated. A single product concept is then selected for further development. (Ulrich and Eppinger, 2008 p.16). Identified as a conventional phase, '*concept development*' is a front-end activity consisting of a variety of activities acknowledged in the adopted model in Figure 2 by Ulrich and Eppinger (2008) with the area of research interest highlighted. For this study, specific attention has been paid to the area of *'concept development'* and *'concept selection'*.

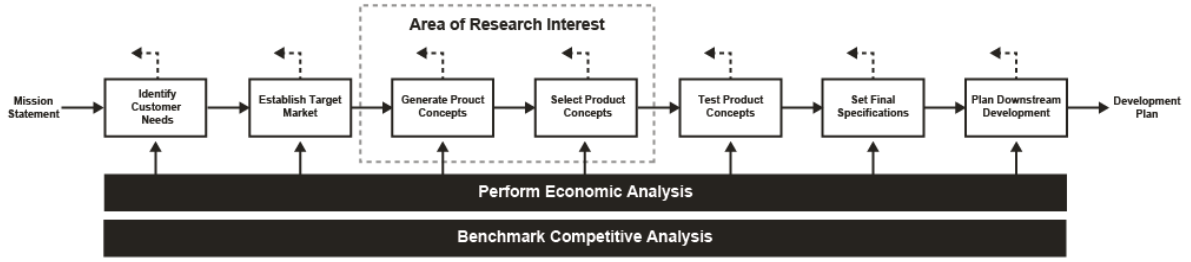

Figure 2. Adopted Concept Development Process Model (Ulrich and Eppinger, 2008)

'Concepts' should be established to assess physical principles that affect their performance and anticipated function, with the assistance of additional rationale development (Ullman, 2010; Ulrich & Eppinger, 2008). These front-end activities generation involve the synthesis and determination of possible solutions which are subsequently narrowed down, concepts eliminated and the identification of the preferred and most appropriate concept(s) to move forward (Ulrich & Eppinger, 2008). The phases appear to offer the opportunity for a large proportion of the initial key design decision-making by practitioners to be made when exploring the space for product concepts, in this case FMCG packaging. Nevertheless, the use of design process models is that they are not accurate representations and are to general to apply to the problems in 'real-life' design situations but can offer guidance during product development (Eckert & Stacey, 2010; Wynn & Clarkson, 2005).

2.4 Design Management in FMCG Packaging Development

Packaging research has received extensive attention in both theory and practice (Azzi et al., 2012). Various models attempt to visually display and help understand the functions packaging serves. At its most basic level of understanding, packaging is a logistical and marketing tool. Packaging should protect and preserve product through the supply chain and promote the product to the end consumer (Prendergast & Pitt, 1996). Models (like design process models) have been formed to help understand the principles applicable to packaging design practice. Research identifies several elements that affect the consumers decision-making process including visual elements, structural design and informational cues (Ampuero & Vila, 2006; Ryynänen & Hakatie, 2013; Silayoi & Speece, 2007). However, these models do not appear to take into consideration broader contextual influences.

Research by Azzi et al. (2012), Mumani & Stone (2018) and Johnson et al. (2019) provide insight into much more rigorous and holistic in-depth understandings of the factors affecting packaging design. Effort has also be made on understanding and developing more industry specific models to help recognise product development and design management for FMCG product(s) and associated packaging (Bruce & Daly, 2007; Simms & Trott, 2010, 2014a; Vazquez et al., 2003). Simms and Trott (2014) provide a '*grounded framework for packaging management'* in NPD providing insight into three distinct levels of packaging development: skin deep, body modification and format change. The emphasis within many firms is primarily on changes to '*skin deep'* or '*body modification'*, while technological and format changes are overlooked. This is due to the *"risk-averse and ad-hoc"* attitudes associated with packaging development and decision-making being addressed by non-packaging specialists (Simms & Trott, 2014 p.2020). Although briefly addressed, less consideration has been paid into the role packaging organisations and their design practitioner or design teams remaining relatively unexplored although these are the professionals involved of *"defining directions" in the packaging industry"* as research has been orientated towards theory and artefact driven (Ryynänen & Rusko, 2015).

For the purpose of this research, focus is orientated to the *'concept generation'* and *'concept selection'* from a design practitioners perspective. Analysis will be presented on the influences and factors that subsequently affect packaging concept rationale and decision-making by these practitioners in the synthesis and determination of concepts to meet client needs. Furthermore, analysis of how these concepts are subsequently narrowed down and eliminated will also be investigated. These phases outline the opportunities for practitioners' to explore the brief; and, how design concept options evolve towards a final concept

selection. To date, little attention appears to have been paid from a practitioner perspective on these design activities; and, how the process of design within FMCG is managed (Ryynänen & Rusko, 2015; Vazquez et al., 2003). This paper looks to initially explore some of the matters not yet addressed.

3 Method

This study aims to document and explore the design practitioner within the context of concept development process in FMCG packaging design. The study was constructed within the procedures of Loughborough University Ethics Committee following its data protection guidelines and approval process (Loughborough University, 2018). From a review of available literature, there appears to be a scarcity of studies available that describe methods for observing practitioner design practice in a 'real-world' situation; or, provide combined task and information capture techniques. The method described here was adapted from the approaches used by Cash, Hicks, & Culley (2013) and Cross & Clayburn Cross (1995) who have presented some research techniques on practitioner design practice analysis and design team observations.

Case method was selected to understand an in-depth analysis of an event (in this instance concept generation and selection) utilising multiple evidence perspectives (Martin & Hanington, 2012; Simons, 2009; Yin, 2009). The research was conducted within a large packaging manufacturer based in the UK. The company specialises in FMCG food and beverage packaging providing design-led packaging solutions for the UK and European markets. Access was given to three teams at three UK sites, including their design studio facilities, over three months. The study triangulated results from four phases of data collection: 1) unobtrusive direct observation, 2) archival document analysis, 3) individual participant observation and; 4) semi-structured interviews.

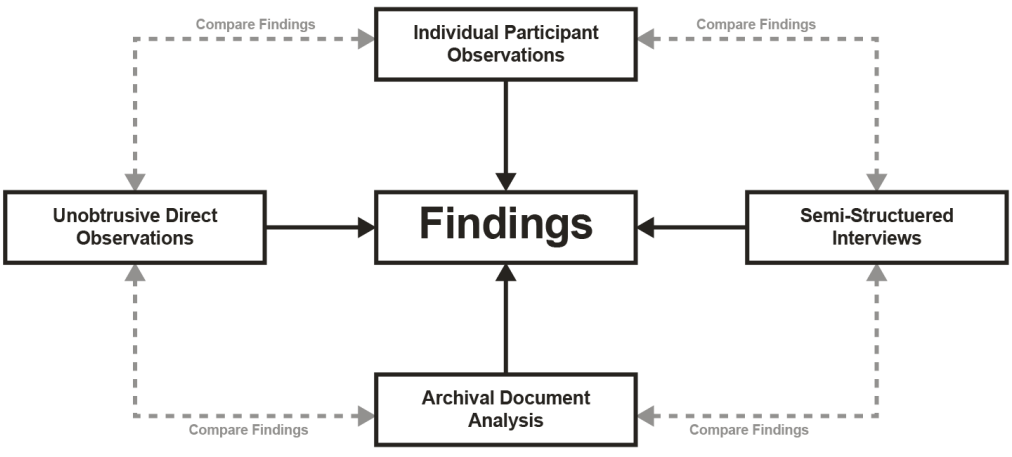

Figure 3. Proposed Convergence Style Method for Case Studies Analysing FMCG practitioner Design Practice

These methods were selected due to the inherent complexity of the design process and the pace of the industry (Vazquez et al., 2003). Various sources were collected at different points dependant on the availability of practitioners. These elicitation methods were utilised in a convergence style offering multiple source-evidence comparisons as depicted in Figure 3 (Yin, 2009). The intentions were to analyse the design practice activities of the FMCG practitioners in their 'real-world' environment.

3.1 Phase 1: Unobtrusive Direct Observation

Direct observations may take a variety of forms, ranging from casual observation through to more systematic observations utilising worksheets, checklists and other forms of codifying behaviours (Robson, 2002; Yin, 2009). To provide a more holistic inquiry of packaging design practice, a research operator observed the day-to-day running and interactions of a design studio to obtain a naturalistic perspective of the studio's workings of the main design team with the most substantial amount and diverse range of designers in the organisation. A closed setting with an overt, unobtrusive role for the observer was chosen (Robson, 2002; Bryman, 2012). Due to limited access to the organisation, a micro-ethnographic technique was applied to the observation of the design practitioners within the organisation (Bryman, 2012). Seven complete working days were observed. These included: project work observations, employee-to-employee studio interactions; client meetings; and, client calls. All of which were agreed in advance with senior management. An observational protocol was created before the study that included a nine-point descriptive observation criteria, as developed by Robson (2002). Six additional aspects for design team observations were taken into consideration from research by Cross and Clayburn Cross (1995) when conducting the direct observations.

3.2 Phase 2: Archival Document Analysis

The researchers were provided with previous conceptual design work projects (n=18) from the organisation's archive (Yin, 2009). The examples involved work from both conceptual and structural designers. Eighteen projects produced by the participating designers were selected and distributed into three categories by design outcome: best (n=6), average (n=6) and poor (n=6) design outcomes. Analysis was undertaken on the design outcome and the associated design briefs with each project. These were used to provide insights into the work-as-done activities of the designers and application of design process. Some projects were later discussed in interviews (phase 4) with the design practitioners.

3.3 Phase 3: Individual Participant Observation

Individual participant observation, adapted from Dorst and Cross (2001), was utilised to assess individual practitioner activity across sites (n=6). The principle researcher worked alongside a product developer to establish a 'real-life' brief for a new product development in an FMCG food category. Information gathered from British Standards BS7000 series and relevant literature assisted in brief formulation (British Standards Institution, 2015 p.38-39). The brief included an outline of the product values, design task and brand language requirements (Figure 4). To ensure high-quality design outcome, a pilot study with one participant designer (PD001) was used as a baseline for the refinement of the main study's protocol.

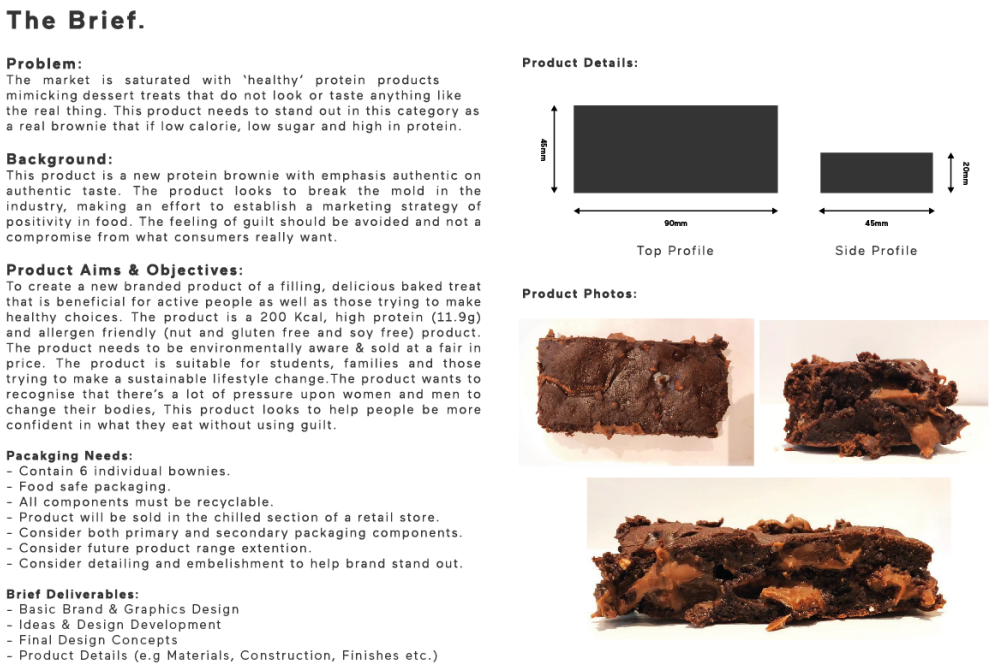

Figure 4. Extract from Participant Observation Design Brief

Activity packs given to the designers included a design brief, design diary (for notes and sketching), category competitor products, product ingredients, nutritional information, physical product samples and ethics documents which were all prepared in advance to the days of observations. The principle researcher's role was a 'Non-Participating Observer with Interactions' assuming the 'client' role acting as the point of contact to answer queries. Participants would be working at their day-to-day design environments to simulate a 'real world' design activity over three hours using equipment and environments they were familiar with to produce an accurate representation of their normal design practice activities.

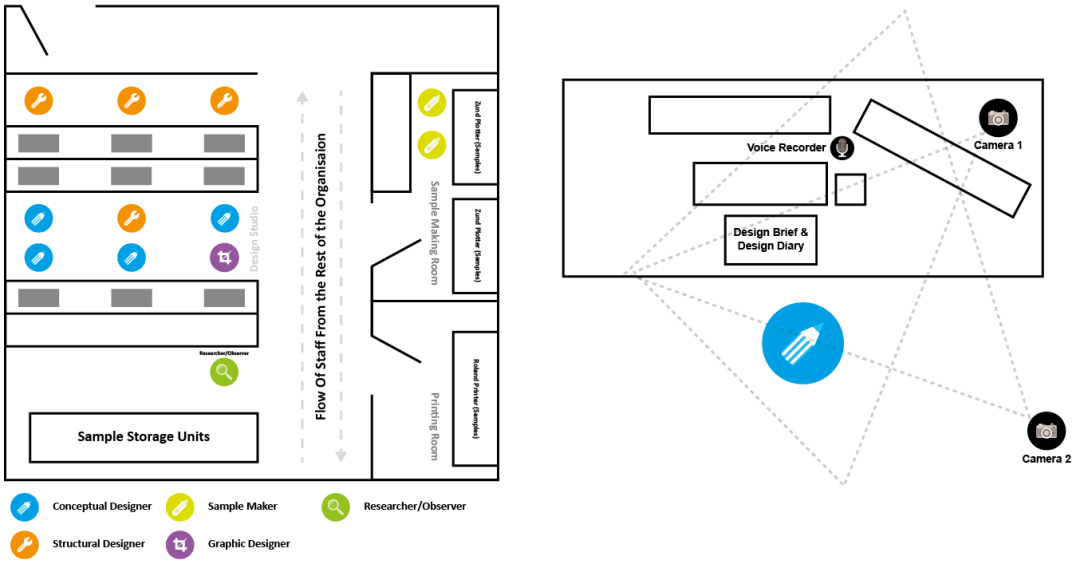

Figure 5. Example Direct Observation & Participant Observation Capture Techniques (PD001)

Observational protocol was adapted from Creswell (2014 p.171) and Zeisel (2006). This provided dimensions for the descriptive observation with: reference codes, site sketches. Information about desk setup, camera location, audio recording devices, and locations of the participants being observed was adapted from Cash et al. (2013) (Figure 5).

3.4 Phase 4: Semi-Structured Interviews

Semi-structured interviews were conducted with sample of design practitioners (n=11). Interviews allow for the collection of personal accounts of each designer's experience, opinions, attitudes and perceptions (Martin & Hanington, 2012 p.102). Data collected included descriptions about designers from different disciplines within the company including structural, conceptual and graphic design using a purposive sampling criterion. The researcher considered the context of each interview, as the accounts given to the researcher may be adversely influenced by the fidelity with which designers may recall previous events; and, may attempt to post rationalise the event to render themselves more intelligible (Crilly et al., 2009). A frame of questions was produced containing five categories to provide interview intent (Table 1). Prompts were also produced to facilitate the interviews as well as physical packaging elicitation material provided to each designer to help as reference points when describing the events within their design process (Creswell, 2014; Robson, 2002).

Table 1 Interview Question Categories & Purpose

Stage	Question Category	Question Category Purpose
Stage 1:	**General Participant Information**	*Identify relevant background information about the participant including gender, age, design education, job role, previous experience, specialisms and design tools used.*
Stage 2:	**Aspects of design practitioners think are important**	*Understand what 'good' design' is to the practitioners. This will include discussion on the role packaging has from their perspective and what factors they think directly affect the consumer.*
Stage 3:	**Limitations to the Practitioners Design Process**	*Understand what limits practitioners from a personal and organisational/industry perspective including storytelling opportunities to provide context to situations described.*
Stage 4:	**Hypothetical Design Process Walkthrough**	*Expand beyond the use of just purely verbal report. Participants are provided with sheets to sketch, write and elaborate on concepts discussed and add a practical element to the study. This will also be used as a break to separate purely verbal reports with the participant.*
Stage 5:	**Practitioner Research, rationale & Validation of Design Decision-Making**	*Understand the ways practitioners research, validate and rationalise their designs concepts to themselves and to clients. Understand their awareness of methods of validation and communication to clients.*
Stage 6:	**Design Tool & Resources Inquiry**	*Understand what tools and resource practitioners currently have and use. To understand what their ideal arsenal might be to complete design work effectively.*
Stage 7:	**Elaboration & Other Comments**	*An opportunity to elaborate on any of the previous questions and for practitioners to ask questions or inquire about any of the concepts discussed.*

4 Case Study Analysis and Preliminary Findings

Data Analysis employed an inductive *"ground up"* strategy where key concepts emerge from closely investigating the data collected. Explanation building, and logic modelling were used as analytical techniques to build an explanation of phenomena. This enabled the researchers to understand the tasks taking place, document links and events in chronological order and identify areas to improve organisation performance and make recommendations for future actions (Yin, 2009 p.147-159). This was used in understanding the design process and influences that affected the various stages. Qualitative content and thematic analysis were employed on the convergence of evidence. An analysis model was also adapted (Figure 6) to code and analyse the data (Atkinson, 2002).

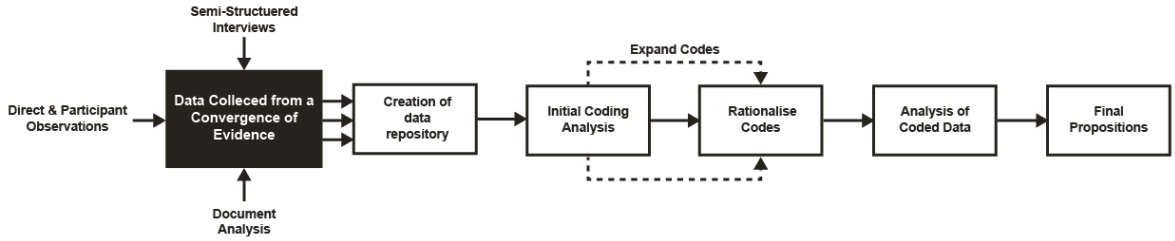

Figure 6. Adapted Model for Case Study Data Analysis

Excel meta-matrixes and Nvivo 11 were used to help manage data, identify themes and code data. Existing qualitative case studies in the area of product design and FMCG packaging were also utilised to aid in a presentation of a narrative description of findings (Crilly et al., 2009; Ryynänen & Hakatie, 2013, 2014; Vazquez et al., 2003).

4.1 Preliminary Data Analysis

To interpret the data collected, a detailed review of field notes, interview transcripts and project documents was undertaken. These contributed to a greater understanding of practitioner rationalisation and decision-making in concept generation and selection. Reoccurring themes and critical insights were highlighted for further analysis. Interesting areas of discovery were also highlighted for possible further investigation post-analysis. This study is part of an ongoing PhD research programme and the data presented here contains initial conclusions from the analysis from one industry case. It is evident that some distinct themes have emerged. However, additional data should now be collected from other UK based packaging designers and FMCG companies to help validate and generalise some of the preliminary findings in this study. Based on the data collected, preliminary conclusions drawn are outlined in Figure 7.

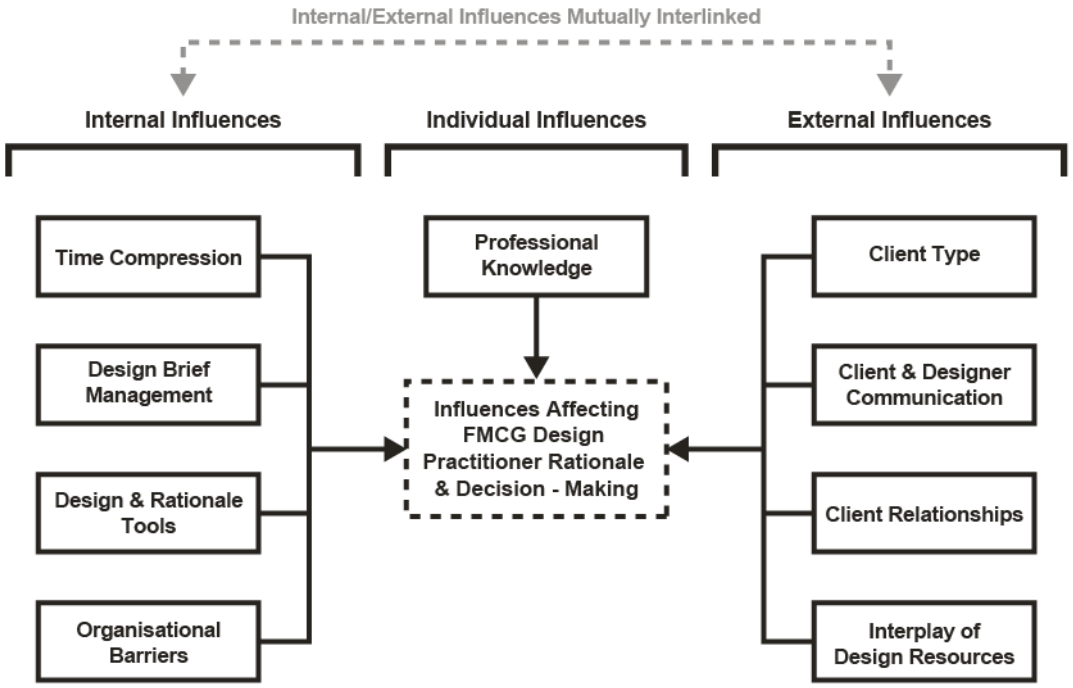

Figure 7. Preliminary Model of Influences affecting Practitioner Rationale and Decision-Making in FMCG Packaging Development

4.2 Preliminary Case Findings

A short narrative of each theme is presented of each of the findings from the evidence collected from across the research methods used for data collection. Specific example quotes from the semi-structured interviews (phase 4) are presented and used to support and provide context to the themes described.

4.2.1 Time Compression

The primary influence affecting practitioner rationale and decision-making was the recurring and increasing burden of '*time compression'*. Time frame and the associated expectations of design briefs appeared to affect design outcome significantly; and, the ability for practitioners to effectively rationalise concepts.

> *"...back in the day two weeks, now two to three days....it's the supermarkets that drive it and put pressure on the companies...it's hard to say to them, do you want something really good or something mediocre..."*
>
> ***(PD008, Structural Designer)***

Short deadlines for design activities seem to be particularly prevalent in the FMCG industry. Driven by industry culture, increasing pressure from UK retailers on their suppliers causes a reduction in time allocated to packaging concept development. Practitioners repeatedly expressed frustration over the time provided to complete briefs for the expected level of design outcomes by clients.

“Time is clearly driven by the culture [FMCG Industry]…the retailers drive the perceived need to have everything yesterday… we are often some of the last people in the chain…there hasn’t been any time allocated for any sort of feedback loops or any problems that we may encounter…”

(PD007, Design Manager)

The client-driven service attitude of the FMCG industry means expected turnaround for design projects is short. The need for a greater understanding of realistic expected outcomes and timeframes is evident. However, the competitive nature between design services could imply that firms will accommodate these time compressed deadlines to secure design work.

4.2.2 Design Brief Management

Management and quality of design briefs appeared to impact practitioner decision-making. A high-quality brief was said to include sufficient information of the intended product contents and its dimensions, design direction, product positioning and filling/production requirements. This would allow for the generation of appropriate design concepts within the timescale given. Often, very little information was provided on design briefs or sometimes it was missing altogether. Design instructions within the briefs observed included common, vague directions such as *‘blue-sky thinking’* ,*‘eye-catching’* or *‘innovative ideas’.* Whilst this could be seen as providing creative freedom in concept generation for designers; in turn, this could be seen as potentially restrictive due to the lack of more specific direction. This could potentially lead to increased brief misnterpretation, as in some cases observed. Ill defined or missing information from briefs sometimes led to designers spending valuable additional time searching for or requesting this information. This could limit the designers ability to produce well-rationalised design concepts due to uncertainty in their propositions.

“They were pretty vague in what they wanted...we had to research what products they produced...we just threw everything at them...and hope some of it hits the mark...”

(PD010, Conceptual Designer)

Parameters were evident in the formal briefing process used by the company, employing specific software and protocols. However, information was still often absent or incorrect. Comments in briefs indicated designers to discuss the project with other staff members for extended details based on phone calls or emails often substituting the formal briefing process. When possible, especially with more complex and demanding briefs, designers would insist on inclusion in the client facing briefing to try to actively try and eliminate some of these inefficiencies. However, this was not always possible.

“…to get the best designs is to get a good brief and ask the right questions as well...a long-term brief that may take a couple of months or 2 or 3 weeks Those are the major ones; and, the ones where I almost insist on being there.”

(PD009, Design Manager)

Multiple individuals were involved in acquiring, documenting and delivering brief information to the design teams. Briefs were often taken by key account managers or other internal/external sales representatives who were not fluent in design or departmental

terminologies. Essential information could be misconstrued or inproperly documented altogether resulting in designers misinterpreting the brief. This was reported to be a barrier to effective design decision-making and impacting concept design outcome. Designers would have to find additional information, either through repeated contact with account managers or by contacting clients directly. In one particular direct observation, a designer was activly criticized by a client for their design output due to misinterpretation and brief communication failures causing confusion and frustration to the designer and design team.

> *"…it's down to the mindset of our customers and staff. Do they know what a designer needs to know, probably not...at the end of the day they don't have technical backgrounds, they don't have design backgrounds…"*
>
> ***(PD004, Design Manager)***

In some cases observed, the briefs would be altered (for example, intended product contents or design outcome delivery date) without informing design practitioners. In other cases, changes made in client-facing meetings were not always formally documented. This resulted in miss-match of expectation potentially causing errors in concepts produced. This, in turn, generated frustration, wasted time and communication breakdown during the concept design process.

4.2.3 Client-Designer Communication

Continuing from the theme above & highly linked, communication streams between designers and clients impaired decision-making. Although design briefs were provided for task clarification, many of these briefs were initially interpreted by non-experts, key account managers. This linear method of information management and inefficient translation meant details were often missed that may be useful to the designer fully understanding the intended design outcome. The lack of information can have a profound effect on the interpretation of briefs.

> *"…account managers take briefs...they won't necessarily ask the right questions...if I'm not present or another designer is not present, the likelihood of us hitting the brief is less..."*
>
> ***(PD009, Design Manager)***

The use of these multi-layer communication channels between client and designer meant essential information was sometimes lost, as well as the opportunity to gain practical and timely feedback from clients. This often meant that designers would not know if clients were satisfied with their design rationale and associated outcomes.

> *"…I send off all my work [to the account manager]...there is no talking to the client...getting feedback on work and how we can improve that in the future."*
>
> ***(PD010, Conceptual Designer)***

4.2.4 Client Type

Two roles are prominent in the delivery of design briefs; marketing and technical perspectives. Each held different priorities when it came to 'good' design outcome and expected decision-making from practitioners. Marketing perspectives focused on visual design elements and shelf presence. Packaging technologists and procurement/packaging buyers prioritised supply chain feasibility, cost and production constraints tending to be

adverse to the adoption of new packaging concepts and moving away from more generic ‘off the shelf’ and well-established formats.

> *“…it is important to know the audience before if you are presenting…you need to design something that will appeal to all parties if you can...”*
>
> ***(PD009, Design Manager)***

Designers sometimes dealt with retailers directly. This often produced a more proactive design approach. This potentially increased practitioners’ ability to validate and rationalise design concepts as time pressures could be relieved. There was greater opportunity for feedback and design iteration.

> *“ …we then had some customer feedback. We did some insights, some more ideas, a consumer panel to validate it...because that was direct with Retailer X they saw the value and importance…”*
>
> ***(PD004, Design Manager)***

Although the suppliers of the retailers would tend to have more control over packaging format choice used in a concept or final product. Design activities directly with retailers appeared to provide a greater opportunity to provide more considered design solutions without the additional influence of product suppliers.

4.2.5 Design and Rationale Tools

Tools varied greatly depending on the time and resources allocated to design briefs. The use and reliance on tools also varied between practitioners. However, it was apparent that there were some common themes which they shared. One of these was the use of acronyms to provide a set of general principles for the designers to follow and execute design activity learnt in either in design school education or on specialist courses.

Designers would also keep themselves informed through generic day-to-day desk based research of news articles and industry specific forum sites on industry trends, areas of debate (such as the single-use plastics debate) and generic design research into new product/packaging developments. This would be included in many office based conversations and included in their outside of studio work activities as well. In time compressed situations, research was often limited to desk-based research activities using online resources such as ‘*Mintel’*, ‘*The Dieline’ ‘Instagram’* and *‘Pintrest’* to inspire ideas and concept generation. This was also used as sources to support design concept rationale. Competition analysis was often conducted before starting any concept development. Some practitioners expressed they designed in isolation initially as not to be biased by preliminary exposure to potentially *‘restrictive inspiration’*. In many cases where time compression was reduced, research activities included gathering marketing insights and in-store visits. Observing consumer behaviour and packaging interactions allowed practitioners insight into consumer product engagement; and, for whom they are designing for.

> *“...they [marketing] are generally observing consumer behaviour, people attitude, which demographics are walking in the store.... I am observing how they are using the packs...”*
>
> ***(P004, Design Manager)***

Social media was a key tool utalised by practitioners with recurring use of *'Instagram'*. This site can easily be used to navigate food and design trends through the search of hashtags and influencer blogs. This was specifically used in ideation support and mood board development.*'Trend boards'* produced internally was often utilised. Developed through primary and secondary research into the global fashion trends, these help support design decision-making. These contain colour palette swatches, contextual imagery and packaging print finish applications to support design decisions in client presentations.

> *"…if we are proposing new graphic ideas or print finishes; it is useful to have the trends to show what we have done..."*
>
> ***(PD003, Conceptual Designer)***

FMCG NPD exhibitions were visited to gain insights into product categories practitioners design for. This allows for improved alignment of the designs they produce; and, further, inform practitioners within their area of design expertise. New products require new packaging solutions. When FMCG designers do not have time to do research they can utilise this experiential knowledge.

The use of paid stock imageary and vector sites were also used regualy in the design practice of practitioners to complete artworking tasks. This appeared to help save time in design practice activities whilst still producing high quality artworks. This also allowed those with less experience in vector artwork creation to manipulate existing vector designs. The use of high quality stock photos also meant realistic packaging artworks could be produced without the need for product photography to be produced and, help save design activity time.

4.2.6 Use and Reliance of Professional Knowledge

Designers often draw from previous experiences and their own knowledge during concept development and selection. Although design and rationale tools were available, in many cases practitioners often relied heavily on their professional connoisseurship. From decision-making witnessed, especially when time compressed, designers drew from this. More experienced practitioners relied more on this knowledge-base.

> *"... I don't really go on marketing, I kind of just go for it [sic]"*
>
> ***(PD009, Structural Designer)***

Junior practitioners would seek validation of concepts through the affirmation of senior designers to make sure the concepts were feasible and appropriate. This was not mutually exclusive to just juniors. Participants expressed knowledge sharing and opinion consensus was a key method for validating and rationalising concepts.

> *"…people within that team go 'that looks awesome' , 'what's your thought on that'; or, even someone in a different section of the business walking past going 'what's that for'…the feedback and reinforcement is really helpful. [sic]"*
>
> ***(PD010, Conceptual Designer)***

Although the use of additional validation methods (marketing insights and design research methods), practitioners on a day-to-day basis relied heavily on idea recycling and their expertise. This was particularly prevalent in situations with time and resource limitations.

"…originality [is lost]...if we are struggling for time we might reuse some things that we know that work."

(PD003, Conceptual Designer)

4.2.7 Client Relationships

Recurring design work often means a professional relationship forms between designer and client. In some incidents, this meant information would be attained easier; or, practitioners better understand production capabilities of the clients packing lines within their supply chain. This in cases discussed and observed meant designers were able to quickly justify their decision-making because of this previously attained knowledge from that relationship. However, designers would become accustomed to client requirements and limit conceptual design decision-making.

"…they are not going to go for it because they are all about cost effective... we know them over the years, they never change."

(PD008, Structural Designer)

Although potentially limiting, this can increase clients trust in practitioners for delivering feasible, timely concepts leading to design outcome adoption. Opposing this, this could also drive unrealistic expectations of the designers and increased expectations on the design output time-scale, deigns work from these clients would often be expected as a priority and produced rapidly.

4.2.8 Interplay of Multiple Design Resources

The role of the 'packaging designer' is often described within literature as a holistic, multi-disciplinary role appearing to encompass both structural and graphic design knowledge. However, in reality the role of the packaging designer requires specialist technical knowledge. Multiple roles are assigned to facilitate the industrial design process, such as graphic, conceptual, structural and technical/production designers all contributing to the final designed artefact. However, in this case, majority of these roles appear to sit within the Original Equipment Manufacturers (OEMs), such as packaging converters or manufacturers. This could affect the other external designer's decision-making and rationalisation techniques due to a potential lack of knowledge or expertise. For example, designers within independent design agencies relying heavily on OEMs for concept feasibility in later stages of concept development or in-house design resources sitting within suppliers of retailers contributing to the design process.

"…customers have spent tens of thousands with design agencies…they would even come up with some flat blank proposals. You would look at it and go, that's never going to work in a million years…"

(PD007, Design Manager)

It is evident that graphics and structural design should be considered in synergy, yet this seems to not be the case in industrial practice. Linear approaches were undertaken where the structure would be predetermined and graphics applied to structures built first or 'off the shelf' formats selected with accomodating graphics. Design agencies were criticised for impractical structural designs in concept development, such as improper consideration of

colour and print finish for pre-press and overall structural feasibility, causing frustration to OEM based design practitioners when being handed initial concepts to develop further.

Decision-making appears to be hindered by a lack of communication and willingness to collaborate between these parties in accounts discussed. The linear, and sometimes isolated, design process between design resources could restrict efficient decision-making due to this lack of parallel and collaborative working activities.

> *"…if you cut them out we have all the expertise here...they look all shiny in their London office…however, there is no basis in packaging... even if there was more of a dialogue between those three people [agency, OEM and brand]…"*
>
> ***(PD003, Conceptual Designer)***

OEMs attempt to help realise initial concepts to make them commercially viable. However, this disconnect shows clear knowledge gaps in concept development of certain design resources affecting rationale and decision-making of the practitioners involved. Even with criticism toward design agencies from an OEM practitioner perspective, an element of necessity and respect towards agencies was also documented through marketing/category managers observed from client facing meetings.

> *"...marketers will go to an independent design agency because they are not going to be force fed a product [packaging concept], they want to have something that is the best solution for them..."*
>
> ***(PD007, Design Manager)***

4.2.9 Organisational Barriers

Although designers would produce more complex designs requested by clients, pressures from *"shop floor"* to produce more economical designs to meet key performance indicators (KPIs) was a barrier against decision-making. Designs that were less complex to make could be produced and assembled quicker and more efficiently.

> *"...we were told not to go down the complicated route and keep things straight forward... their volumes are going to be smaller, and they are measured on their KPIs based on volume not based on profit..."*
>
> ***(PD006, Structural Designer)***

FMCGs in their nature are production orientated. It appeared that from the perspective of those not involved in the design process, such as production managers, would not see the value of more complex or time demanding concepts. These designs would maybe have more significant downstream economic benefits, for example, gaining the trust and repeated design work of a new client. Even though the design practitioners' proposals maybe feasible, the unwillingness to accommodate the design by production was evident.

> *"...it's a bit of a pain, but we can do it. Our competitors can do it, but they [production] refuse to do it here because it slows down production..."*
>
> ***(PD008, Structural Designer)***

Although design practitioners would want to push complexity to accommodate the requests and needs of clients preferred design concepts, manufacturing and technical restrictions of the firm would be a key restriction in decision-making. Some concepts were just not feasible or too costly to produce in either a specific material or on the machinery used within the packaging converter.

5 Discussion and Future Work

FMCG packaging is a commercially and production directed form of design practice. Great care must be taken by design practitioners when delivering feasible, cost-effective; yet, highly aesthetic and desirable design concepts. A robust and comprehensive method of observing FMCG design practitioners in a 'real world' environment has now been established. This research has identified nine preliminary categories influencing practitioner rationale and decision-making (Figure 7). Marketers, brand and category managers in NPD appear to lack technical packaging design knowledge relying heavily on decision-making and rationale of these designers. Many influences appear to affect the decision-making capabilities of FMCG designers as discussed; yet, the industry culture hinders their activities. It is apparent that potentially reducing the '*time compression'* on practitioners would allow for iterations of concepts; and, in some cases for ideas to be tested at this early stage . However, this would need retailers/brands to be convinced to invest that additional time. In shorter design projects, this would not be feasible.

In the case presented, practitioners are adapting to these increasing time pressures by producing tools to aid in concept rationalisation. However, there is still a heavy reliance on a practitioners' professional knowledge. Non-experts and design practitioners should also look to develop a more common language to more effectively understand what needs to be documented to efficiently specify design work to practitioners; and, not further restrict short timeframes for design work. Lack of communication and knowledge transfer between critical parties has led to many situations where feasibility is not addressed early enough. Concepts produced outside of OEMs means additional time to redevelop concepts for commercial viability, in some cases drastically changing design outcome. This aligns with findings by Simms & Trott (2014 p.2021) where technical development is *"inadvertently overlooked"* in earlier stages. However, OEMs struggle to establish and maintain long-term relationships from a design perspective (Simms & Trott, 2014 p.2020).

For larger projects involving other design resources (such as design agencies), the research could suggest individuals involved in NPD should look to reduce the level of the isolated, linear communication streams and foster a more parallel design process (Figure 8). These individuals should possibly build more significant relationships with their OEMs to address feasibility from the beginning to ensure effective design decision-making and concept rationale to reduce unforeseen time wastage and cost, highlighting the value of good quality design practice. This research aligns with the findings of Simms & Trott (2014) and confirms that packaging development is being overlooked and needs to be managed and monitored with more care than it currently is.

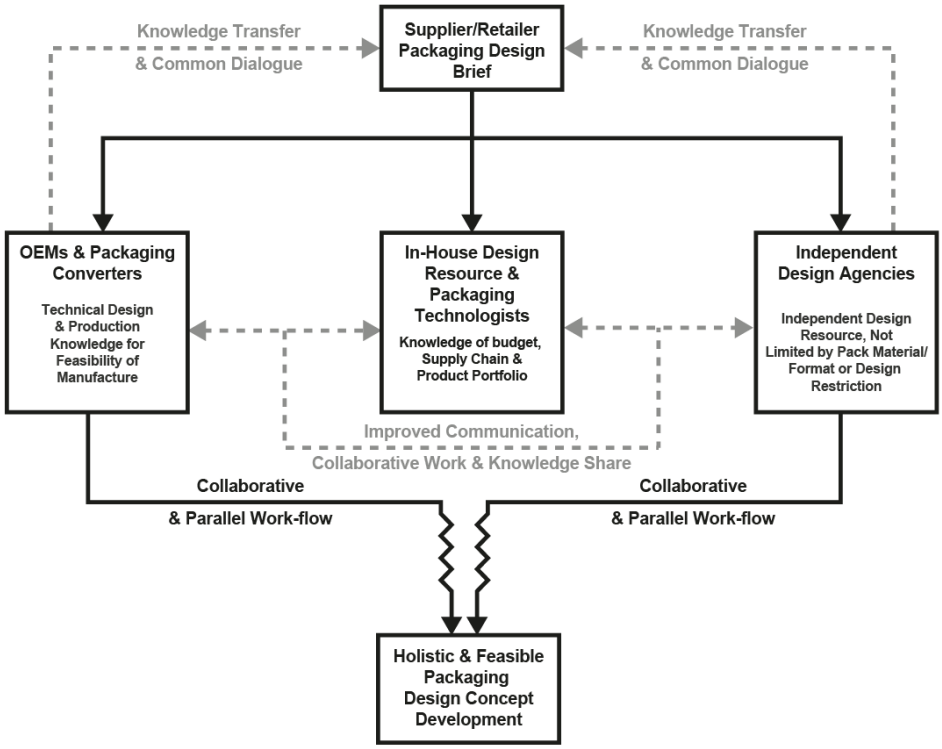

Figure 8. Preliminary Theoretical Parallel Work-flow Model in Conceptual FMCG Packaging Design Development

Now that a robust methodology has been established for the observation of FMCG design practice, future research should look to simulate and employ similar approaches to understand further the factors influencing FMCG practitioner decision-making and rationale. An investigation of a wider UK context would help confirm some of these preliminary findings and see if they are shared in other UK design resources in retailers, food manufacturers, suppliers, OEMs and design agencies. Additional research should also be undertaken into how FMCG packaging design briefs are formulated, how does this impact design work practice and does this impact communication between designer and client in the concept design process? What are the expected outputs from the designers? This could look to help understand expected design outcomes to improve FMCG design process management.

6 Limitations

This research identifies findings based on one case study conducted in the UK. Although some prior research has been conducted, additional research needs to be undertaken around the UK to be able to generalise and confirm these results. This study should be seen as a preliminary attempt to address the factors influencing practitioner decision-making in FMCG packaging development.

Focus on the design practice of FMCG designers in this case was for food and beverage products such as ready meals, packaged meats, cakes, ambient food products and food-to-go. More effort into other areas of FMCG would be needed to help generalise these results as these may not be reflective of product categories that may have longer development phases not observed in this case.

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The value of Experiential Retail Environments: insight on the existing context

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This paper investigates the value of Experiential Retail Environments (ERE's). Insight from an initial explorative literature review was used to drive a comparative study on the notions of 'value' and 'in-store experience' and how they relate to each other. This integrated a collection of data through sets of interviews conducted with representatives of the three stakeholder groups most concerned with retail design projects: retailers, retail designers and consumers. Results show that the notions of 'value' and 'experience' remain intrinsically person-dependent but that some aspects are generally agreed upon. First, an 'experiential store' is perceived by all stakeholders to be a store that 'does more' (than sell products). It focuses on the customer experience, has a strong link to the brand and is associated with the notion of the 'unexpected'. Second, all groups agree in-store experience is a combination of the service, the environment and the offer but the exact combination of these elements and more particularly the role of the environment varies greatly between stakeholders. Third, the topic of value generated difficulties in discussions and as such remains hard to conceptualize. However, in all cases, a strong link between in-store experience and value perceptions has been identified. Fifth, the three stakeholder groups agree that the physical environment has a key role to play in both of these. Finally, there is currently no systematic approach to experience integration in the retail design process. In most cases, experiential factors are added to a store post concept generation.

Keywords: Experience; Value; Retail Design; Experiential Retail Environments

1 Introduction

Retail designers today face multiple new challenges. First, the retail market is more competitive than ever before. This is partly due to what has been called a 'commoditization' of outlets (Willems, Leroi-Werelds, & Swinnen, 2016), partly due to the growth of online shopping but also to the blurring boundaries between entertainment sectors associated with what is now widely referred to as the 'Experience Economy' (Alexander & Kent, 2017; Csikszentmihalyi, 2000; Petermans, 2012; Pine & Gilmore, 1998; Van Ekris, 2018). Second, the rise of connectivity means customers have become more aware, demanding and value-conscious (Morrell & Goulding, 2017; Sweeney & Soutar, 2001; Van Tongeren, 2013; Willems et al., 2016). In order to differentiate themselves and retain customer shares, retailers have thus turned their attention to creating brick and mortar environments which trigger 'valuable' customer experiences, or what is now commonly referred to by retail

professionals as ‘experiential stores’ (Grewal, Roggeveen, & Nordfält, 2017; Morrell & Goulding, 2017; Vandooren, 2017; Verhoef et al., 2009).

Although this evolution has led to increased interest in academia on in-store experience (Bäckström & Johansson, 2006, 2017; Lemon & Verhoef, 2016; Petermans, 2012; Triantafillidou, Siomkos, & Papafilippaki, 2017) and the value of physical retail (Baker, Parasuraman, Grewal, & Voss, 2002; Davis & Hodges, 2012; Diep & Sweeney, 2008; Willems et al., 2016), in practice, much uncertainty still surrounds experiential retail environments and their value. Retail professionals still struggle to make decisions related to this in their day to day work. Relevant information on the two topics can already be found in marketing as well as interior design literature, both in academic and practice-based writings. However, to date, little has been done to combine this available knowledge and apply it to the practical considerations of the retail design process.

In this paper, we report on an explorative study conducted to provide a more holistic view on the value of experiential retail environments with the goal of being useful to practicing retail designers. Following an initial literature review, an empirical study with representatives of the three key stakeholder groups concerned with retail design projects (retailers, retail designers and consumers) was conducted to complement the available data and thus provide a more comprehensive view on the topic.

2 Theoretical background

An exploratory literature review was first conducted to gather information on the notions of experiential retailing and value and more particularly as these relate to the physical store.

Literature was collected from the two fields most intrinsically connected with the subject matter: marketing and retail design. The amount of academic literature available in both being significantly different, the selection of sources had to be approached differently. For the marketing literature, the review focused on the most prominent and widely-referenced authors. Retail design being quite new as an academic discipline, much less academic literature is available (Petermans & Kent, 2017; Quartier, 2011), but much of the discipline’s knowledge base can be found in more practice-based sources, which were also included.

2.1 Experience

2.1.1 Definition of ‘Experiential Retail Environment’

The most referenced marketing sources touching on the subject make little use of either the term ‘experiential store’ or ‘experiential retail environment’. Instead, other terminologies such as ‘experiential consumption’, ‘experiential marketing’, ‘experiential retailing’ or ‘experiential factors’, ‘components’ and ‘features’ are used (Brakus, Schmitt, & Zarantonello, 2009; Carù & Cova, 2003; Gentile, Spiller, & Noci, 2007; Holbrook & Hirschman, 1982; Verhoef et al., 2009). However, in recent years, marketing literature has seen an increased use of these two specific terms. The authors using them give some insight as to what they might refer to but do not provide a clear definition as such (Ballantine, Jack, & Parsons, 2010; Bustamante & Rubio, 2017; Foster & McLelland, 2015; Klein, Falk, Esch, & Gloukhovtsev, 2016; Sachdeva & Goel, 2015).

Similarly, in academic retail design literature the two terms are rarely used and tend to be conceptualized rather than defined (Petermans, 2012; Petermans & Kent, 2017). In more practice-based retail design literature, however, ‘experiential store’ and ‘experiential retail

environment' are commonly used expressions. Once again, no set definitions are offered but the authors usually do provide insight through good and bad practice case studies (Arrigo, 2017; Bain, 2017; Brown, 2017; "Les 5 projets de shopping expérientiel qui ont marqué 2017," 2018).

Review of the combined literature, highlights a lack of consensus thus making it difficult to set a clear definition for the term ERE, although an implicit notion of a 'store that does more (than sell products or services)' seems to exist across all sources.

2.1.2 Experience integration in retail environments

Beyond looking to define it, multiple marketing studies have also analysed how experience can be triggered in the physical retail context. These can generally be grouped in two categories: more 'conceptual' studies on the underlying perceptual mechanism of a customer's experience (Fiore & Kim, 2007; Kaltcheva & Weitz, 2006; Kim, Cha, Knutson, & Beck, 2011; Klaus & Maklan, 2013; Schreuder, van Erp, Toet, & Kallen, 2016) and studies on specific components of the store environment which can activate this experiential process – typically atmospheric factors (Babin & Attaway, 2000; Ballantine et al., 2010; Turley & Chebat, 2002; Walsh, Shiu, Hassan, Michaelidou, & Beatty, 2011).

In her research on customer experiences in retail environments, Petermans (2012) has contributed considerably to the academic retail design literature on the topic, setting important foundations. One important contribution is her visualization of in-store experience through a number of associated themes. Much has also been written in more practice-based literature to provide insight on how experience should be integrated in brick and mortar stores ("7 Case Studies That Prove Experiential Retail Is The Future," 2017; Bardsley, 2017; Mroz, 2018; Neerman, 2013; Sicola, 2016). Similar to that of marketing, retail design literature also approaches experience integration in the physical store either in broader, more conceptual terms (e.g.: surprise, discovery, immersion) or through the use of specific environmental factors which can trigger customer experience (e.g.: interactive displays, customization stations, scents).

2.2 Value

2.2.1 What exactly is value?

The construct of value has benefited from its own research line in the marketing field and as such there is an extensive body of literature available. This has allowed for a clear conceptualization, also of the more specific notion of 'customer value' (Babin, Darden, & Griffin, 1994; Holbrook, 1999; Jones, Reynolds, & Arnold, 2006; Leroi-Werelds, 2013; Willems et al., 2016).

By comparison, specific research on the notion of value does not currently exist in the retail design discipline. However, some academic literature as well as multiple good practice sources make reference to evaluation criteria for 'good', i.e. valuable, retail design projects which can provide some basic information on the field's view of this notion (Ching & Binggeli, 2012; Knox, 2017; Petermans, 2012; Quartier, 2011).

The differences between the two disciplines create difficulties when trying to compare insights, but some key points can be made. First, whereas marketing research on the value of physical retailing focuses on customer value more specifically, retail design seems to consider value for multiple stakeholders at the same time. Secondly, both fields seem to consider value as a multi-dimensional concept and some consensus can even be found as

regards specific value dimensions or types (Babin et al., 1994; Holbrook, 1999; Knox, 2017; Petermans, 2012; Quartier, 2011; Sweeney & Soutar, 2001). However, as illustrated in table 1, which shows a synthesis of these identified value dimensions and their meaning in the two disciplines, this apparent common ground should be considered carefully as each field still has its own specific understanding, considerations and applications to consider (Doucé, Janssens, Leroi-Werelds, & Streukens, 2016; Knox, 2017; Petermans, 2012; Quartier, 2011; Willems et al., 2016).

Table 1. Value dimensions in marketing and retail design

Marketing perspective	VALUE DIMENSIONS	Retail design perspective
"Excellence" involves the perceived **quality** of the products as well as the service (e.g., interactions with employees)	**FUNCTIONAL**	Functional **performance** of the retail space: how well it meets its purpose
"Efficiency" refers to the perceived **price**, but also the perceived **effort** needed during the consumption experience. The latter relates to the convenience of the store.	**COST-RELATED**	Financial performance of the store: **costs** (of implementation and maintenance) **vs. benefits** (commerciability of the brand)
"**Playfulness**" refers to the perceived enjoyment of the store visit. "**Aesthetics**" refers to the perceived beauty of the store.	**EMOTIONAL**	**Aesthetic** dimension (tangible and intangible) of the physical store: the experience it creates through the senses
"Social value" emerges when a customer's own consumption behaviour serves as a means to influence the **responses of other people**. Often this relates to **status** and the brand of the store.	**SOCIAL**	The retail environment as a **public space**: its role in public interactions
"Altruistic value" refers to customers' perceptions of **ethical behaviour** of the store (e.g., how the store treats employees or suppliers).	**ALTRUISTIC**	The **impact** of the retail space **on the environment, the locality and community** (incl. the regulatory aspects of design)

Source: (Servais, Leroi-Werelds, Quartier, & Vanrie, 2018)

2.2.2 Design for customer value creation

Although designing for customer value creation is a key concern for retail designers, field specific research looking into this does not yet exist. The extensive marketing literature on customer value can however provide some insight. Multiple studies seem to point to two ways in which value can be triggered in the customer's perception: either through a coherence with the brand (i.e. the customer's expectations of the brand as regards the store or consumption experience are met or exceeded) (Foster & McLelland, 2015; Gentile et al., 2007; Keng, Tran, & Le Thi, 2013; Rintamäki & Kirves, 2017; Willems et al., 2016) or through a coherence with the consumer's own self-image (i.e. when they feel the brand, store or

consumption experience matches their personality) (Bagdare & Jain, 2013; Cachero-Martínez & Vázquez-Casielles, 2017; Ottar Olsen & Skallerud, 2011; Sands, Oppewal, & Beverland, 2015; Zarantonello & Schmitt, 2010).

2.3 Research aim

Review of existing literature has provided some insight on the value of experiential retail environments but has also highlighted some gaps in knowledge. First, significant variations between fields as well as between academic and practice-based literature were identified. Second, no clear definition of the term 'experiential retail environment' (or store) currently exists. Third, experience integration in the physical store is approached in different ways. It can at times be addressed in broad terms and at others in quite specific terms. Fourth, due to the differences between marketing and retail design literature, a holistic view on the value construct and more particularly as it relates to in-store experience and the physical environment remains somewhat unclear. Finally, some common ground can be found between the two fields' perspectives on the value construct through its formalization in multiple similar dimensions. However, domain specific approaches and focuses would tend to point towards necessary further investigation on this. Beyond a need to create a more solid academic base for retail design by addressing these identified gaps, it is also important to consider the issues they can generate in retail design practice. How can retail designers create valuable experiential store concepts when the current context seems so unclear?

To address this issue and the gaps in knowledge, an exploratory empirical study was conducted in which the three key stakeholder groups' viewpoints on the value of experiential retail environments were solicited: retailers, retail designers and consumers. Two main objectives were set for this study: first, to compare stakeholder perspectives on the notions of experiential retail environments and value; second, to compare the 'in the field' data with the insight gained through the literature review in order to strengthen it and address remaining uncertainties but also to bring it closer to the viewpoint of practice.

Key research question: *'In practice, what do the three 'key' stakeholder groups (consumers, retailers and retail designers) consider as 'Experiential Retail Environments' (EREs) and how do they approach value when talking about them?'*

This question was subsequently broken up into the following six questions:

1. What is an 'Experiential Retail Environment'?
2. What are the different ways to design in-store experience?
3. What role does the environment play in experience creation?
4. What is value in the shopping context? (And as it relates to ERE's?)
5. What are the different forms value can take? And their priorities?
6. What is the role of the environment in triggering value creation?

To link the research to the considerations of practicing retail professionals, additional insight was also looked for as regards both experience integration and value creation in day to day design practice. To assist in this task, Claes et al.'s 2016 work on defining a 'holistic retail design process' was used as a reference framework. The below model developed through their research illustrates the different phases an 'ideal' retail design project follows.

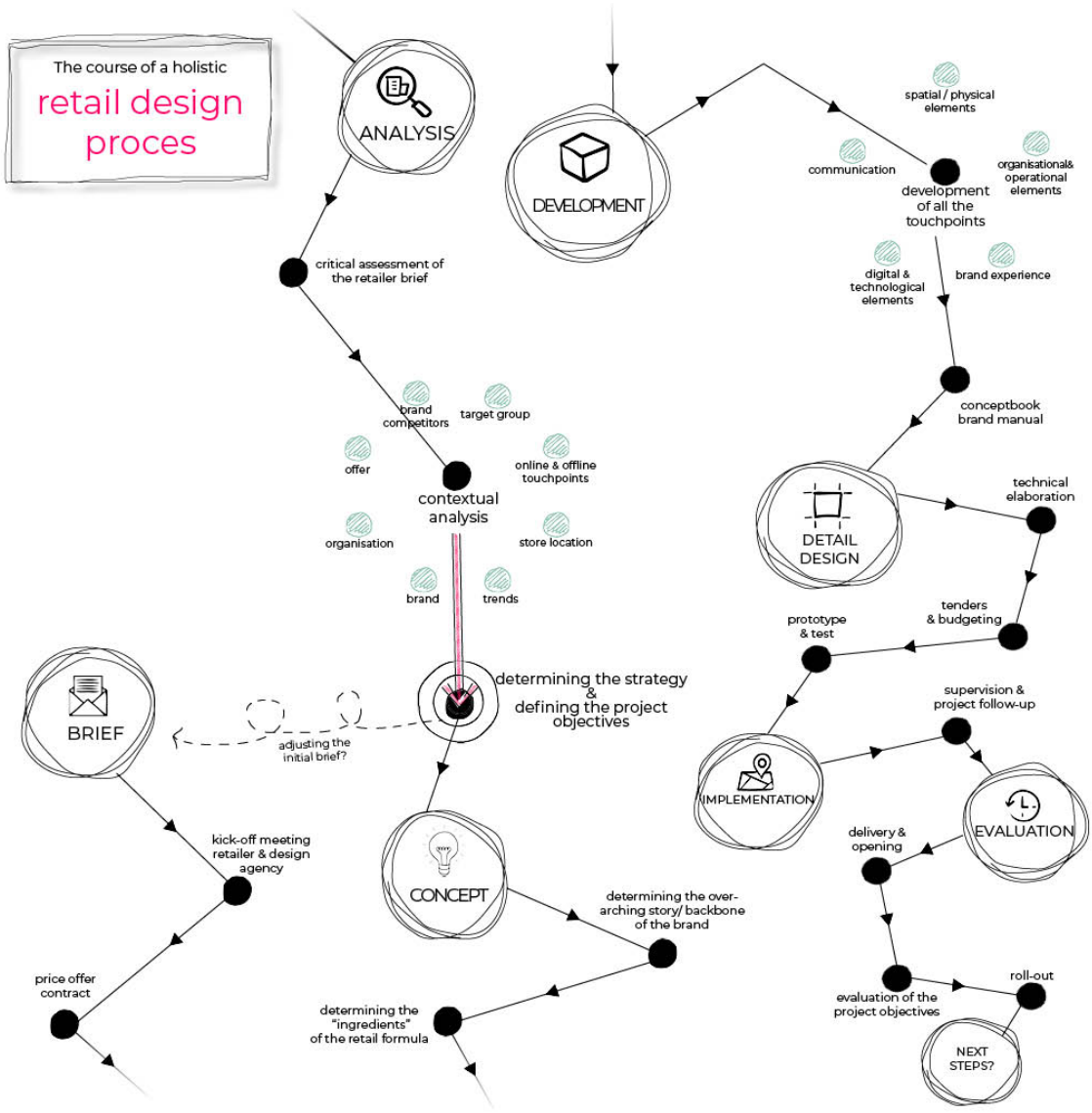

Figure 1. The Retail Design Process Model. Based on: (Claes, Quartier, & Vanrie, 2016)

3 Methodology

This study's approach is exploratory and qualitative in nature, involving data collection via interviews with retailers, retail designers and one focus group of consumers. The decision to make use of a focus group specifically for consumers is linked to the research topic's specificity as well as complexity. As such a more collaborative approach to the discussion was favoured in their case as opposed to one-on-one interviews with the retail professionals who should be more conscious and aware of the researched notions.

3.1 Context

As the study's rather abstract focus could potentially prove difficult to talk about for participants, we decided to provide a context for discussion through a set of physical stores. Therefore, we first selected five retailers with physical environments representing different levels of in-store experiences (low, mid and high experiential), as recommended by local retail professionals.

These five mid-level fashion (and lifestyle) stores were all located in Antwerp, Belgium as it offered high potential for cases that would suit the research (Van De Poel, 2017; Vandooren, 2017). Second, the choice of limiting the stores to one specific retail category was made because, as the research's interest is on the physical retail environment, this would avoid potential deviations in the discussions. In this way, we would limit the risk of people only discussing the product offering instead of the physical environment. Third, the number of stores was set at five in order to offer a wide enough but not unmanageable range of experiences to respondents.

The final store set included three local boutiques (high and mid experiential), one international chain (mid experiential) and one Belgian chain (low experiential). To ensure consistency between groups, the physical environments of the participating retailers were used as a context for all interviews.

3.2 Respondents

Data was collected through interviews with representatives of each stakeholder group. First, face to face interviews were conducted with members of the selected retailers' structures directly involved in the store design process. This included three owners, one head of sales and marketing and one creative director. The interviews lasted between thirty and sixty minutes and took place in their offices (for three, this was within the store context) and a café.

Similar face to face interviews were organized with five retail designers. Two were involved in the design of three of the retail environments in the selected store set. An additional three interior designers known for their work on retail design concepts were asked to participate. These had no prior involvement with the selected retailers but were asked to familiarize themselves with the five stores prior to the interviews. The discussions lasted between forty and one hundred minutes and were conducted in the designers' studios (for four) and at a café.

Finally, for consumers, a focus group with eight respondents was organized. These were recruited using an online registration form (shared via social media and a call-out mail) to ensure they represented (1) the selected retailers' target group (e.g. respondents needed to have visited at least one of the retailers' outlet in the previous year); (2) a good demographic mix; (3) a range of shopping orientations (selection criteria based on: Babin et al., 1994.) The discussion lasted one hundred and ten minutes and was conducted at our university campus. All respondents were asked to have visited the store set in the month prior to the focus group.

The questionnaires for the two sets of interviews as well as the focus group were designed to address the six aforementioned research questions. The selected retailers were asked the questions in the context of their own stores only. The designers who had worked on specific stores were asked to answer in the context of these. The other designers as well as the focus group respondents were asked to answer using the complete store set as context. Data was collected through audio recordings as well as field notes taken both during and post discussions.

3.3 Analysis

The six key research questions were used to guide the analysis process. First, all interview notes, transcripts of the audio recordings and additional material (photos from the focus

group discussion, forms completed during the interviews, etc.) were reviewed to separate the insight per key question. The next step in the analysis process was the reading and multiple re-reading of all the available data to create lists of terms related to each key question. This was done both per stakeholder group and for all groups together. The lists were then analysed in depth to find recurring themes first within individual groups and then between groups.

4 Findings

4.1 Within each group

4.1.1 Retailers

Results show that all participating retailers knew the term ‘experiential store’ but only one actively uses it. When asked to provide a definition, respondents said it is not a ‘traditional’ store, implicitly meaning one focusing only on product sales, but rather ‘a store that does more’. The actual nature of this ‘more’ varied quite a bit between respondents but novelty appeared as a key theme. For the respondents, these stores focus on customer experience which can prove difficult due to the high variability of customer expectations. They also agreed, that irrespective of the approach taken to design it, in-store experience should always be linked to the brand identity and can be achieved by working on a combination of the offer (1), the staff (2) and the environment (3). The environment itself has potential roles to play in experience creation either as a branding tool and/or as a way to please customers. One additional aspect of this topic discussed by retailers is the need to find the right balance between function and experience.

Little agreement was found on the subject of value in the shopping context. Even initial concerns were not always aligned, some respondents focusing first on customer value versus others on value for themselves. When asked more specifically about customer value, respondents often mentioned the importance of customer experience. This typically led the discussions to the topic of the variability of customer profiles, which is seen as a key challenge in retail design. Respondents were generally unable to identify dimensions of value themselves and when asked to rate their priorities based on the dimensions identified in the literature (e.g.: functional, cost-related, emotional, social and altruistic), no agreement was found. There was however some consensus as regards the roles played by the environment in value creation: first and foremost, to match value perceptions of the product but also to match expectations, to match the brand identity and to enhance the experience.

The following additional insight on the retail design process was found. There appears to be no systematic approach to experience integration in the store design process which generally seems to happen post concept generation. Also, though a variety of good practice tools and academic insight exists (e.g. customer profiling, customer journey mapping, etc.), this is rarely used by the respondents.

4.1.2 Retail designers

All members of this group were also familiar with the term ‘experiential store’ and three actively use it. The notions of a store that does ‘more’, focuses on consumer experience (which is related to expectations) and has a strong link to the brand were again generally present in the discussions. However, this stakeholder group had a higher level of consensus as to the nature of the ‘more’ of ERE’s, with most respondents mentioning discovery/mystery, difference, novelty and stimulation. For this group, in-store experience is

designed through a combination of the environment (1) (including the existing building), the brand (2), the offer (3) and the service (4). This mix is highly influenced by the brand and its target customer but the environment itself is quite crucial. Finding the 'right balance' between brand and architecture as well as between function and experience is a major concern.

The participating designers approached value in the shopping context in somewhat broader terms than the retailers, looking at value for all stakeholders simultaneously. Some focused first on the value of the store environment whilst others talked about customer value more specifically. Though less explicit with this group, a link between customer experience and value again surfaced, with the customer-brand relationship contributing to both. Customer expectations and personality matching were mentioned as key factors in the value proposition, making this one highly variable. Retail designers also struggled to conceptualize value in different dimensions. However, when asked to prioritize the literature identified types of value, this group showed some coherence. The crucial role the environment plays in triggering value creation was also highlighted. For designers, it serves as a brand communication tool, as a way to match expectations/value perceptions and contributes to the customer experience. This can be achieved by finding the 'right mix' of functional, aesthetical and experiential (brand relevant) store design factors.

When discussing their design process, retail designers often made reference to the necessity of a close partnership with the retailer. In most cases, it is this one who drives the process as regards design for experience and value creation. No references were made to either existing good practice or academic insight.

4.1.3 Consumers

The majority of the participants were not familiar with either the term 'experiential store' or 'experiential retail environment'. When asked what these could mean, the notion of experience was mentioned multiple times and made reference to a combination of environment, staff, price, organization and location. Although not specifically mentioned there was again an implicit notion of 'more' throughout the discussion. Interestingly, though they were unfamiliar with the term and struggled to define it, respondents were able to provide examples (both in the store set and beyond) of experiential and non-experiential stores, thus showing they do make a distinction. However, the examples given were not always agreed upon, with shopping motivations seeming to impact the decision process. For the focus group, in-store experience is closely related to expectations, personality, feelings and emotions as well as perceptions of difference (uniqueness). It can be achieved by working on a combination of the service (1), the environment (2) and the offer (3) and is often still linked to rather 'traditional' aspects of retail such as price, service or functionality although data suggests these should be combined with experiential factors. When asked specifically to reflect on the role of the environment in experience creation, respondents struggled to limit their comments to environmental factors but the ones they did mention were again mostly 'traditional' components often linked to visibility and circulation.

Discussing the value construct proved the hardest for this stakeholder group. Referencing back to the given store set helped to some degree. Responses point again to more 'traditional' elements (e.g. service, price, quality) playing a key role in value creation although an experiential dimension was also quite present in the discussion. When looking for potential types of value, the focus group mentioned rather practical aspects such as product, environment and service versus the more conceptual dimensions identified in the

literature. As with the retailers, no agreement was achieved when asked to prioritize these. There was also quite a lot of variability in responses as regards the role of the environment in value creation, although all respondents agreed it was a key factor and again that traditional elements linked to circulation and product visibility were quite important.

The participating consumers suggested two adjustments to the current approach to store design: first, more in-store digital integration or at least a more omnichannel approach (although some were nervous about this) and second, more opportunities for personalization.

4.2 Between groups

4.2.1 On experience

Retail professionals are all familiar with the term ‘experiential store’ and some use it actively but consumers are widely unaware of this expression. For all groups, an ERE could be defined as ‘a store that does more (than sell products/services)’, as opposed to ‘traditional’ stores and online shopping. It focuses on the customer experience (which is linked to varying customer expectations) and has a strong connection to the brand. The nature of its additional dimension varies greatly from person to person; however, in all cases it is related to experiencing something ‘unexpected’: difference, novelty or discovery. Although some agreement can surface as to which stores are EREs and which are not, the distinction is not always so clear. Whether a store is experiential or not thus often remains a matter of personal consideration.

All stakeholders seem to agree that in-store experience can be designed through a combination of the service, the environment and the offer. The weights given to each vary from group to group with retail designers clearly focusing on the latter. Interestingly, for this group, the brand was mentioned as an additional element of the mix. In all three groups, it was clear that varying customer profiles impact perceptions of the in-store experience.

Both retail professional groups detailed the environment’s role as a way to enhance the brand or offer. Finding the right balance between function and experience was also mentioned by both. Consumers on the other hand struggled to talk specifically about this topic and seemed to focus on more ‘traditional’ elements of the store design. Their responses would point to the necessity of ensuring the more functional aspects of the store environment are operational before adding the ‘more’ they may expect from a specific brand.

4.2.2 On value

Although providing a context helped to some extent, discussing the value construct proved difficult for all stakeholders (but more particularly so for consumers). As such, the data collected on this topic is more limited and varied, making conclusions harder to arrive at. Still, some interesting points can be made. First, for retail professionals, customer value is not always the main focus (in value considerations). Second, although some differences do exist between groups and even between individual stakeholders on what customer value is, a clear link with customer experience does seem to exist for all. Indeed, value appears to be created when the in-store experience either matches the consumer and his/her expectations/ value perceptions or the brand identity. As customer experience is highly person-dependent and thus variable, so is customer value.

All stakeholders struggled to conceptualize value in different dimensions. The few responses given rarely linked back to those identified in academic literature with consumers focusing on

more ‘practical’ notions. Priorities in the previously identified value types varied greatly from person to person and there was no real agreement within individual groups except perhaps for retail designers.

Across groups, respondents agreed the environment has a key role to play in value creation, but its level of importance and actual role tended to vary between stakeholders and to some degree also between individual respondents. Two roles were mentioned by all groups: to match varying consumer product value perceptions/expectations and to serve as a brand communication tool. As regards specific elements of the store environment which trigger value, most participants still focused on rather ‘traditional’ aspects of store design.

4.2.3 On the design process

Analysis of the data points to three interesting conclusions on this topic. First, a gap between academia and practice seems to exist as available knowledge (from academia as well as good practice) to help in the retail design process is rarely used in practice. Second, all stakeholders are pushing for ‘more’ experience integration with a clear link between this and value creation. Third, although there is a push for it, no clear approach to experience integration currently exists. It tends to be led by the retailers in an intuitive way and in most cases post-concept development.

5 Discussion

Data collected from the empirical study has not only confirmed but complemented the initial insight gathered through the literature review. First, an ‘experiential retail environment’ is indeed considered to be a store that does ‘more’ (then just sell products, the way ‘traditional’ and online retail operate). The study conducted has further added to this by showing that (1) ERE’s focus on consumer experience (which is tightly related to varying customer expectations), (2) they have a strong link to the brand and (3) although the nature of their additional dimension is person-dependent, the notion of the ‘unexpected’ is generally agreed upon.

Second, the study has confirmed that experience integration formalizes itself in discussions either in broad (e.g. difference, novelty, discovery) or specific terms (e.g. references to specific environmental factors) and that this can generate difficulties for concept development. As a result, in most cases it is integrated post-concept generation. Interestingly, the study has brought to light that currently it is the retailer who leads this aspect of the process.

Third, value remains difficult to conceptualize and did not formalize itself in dimensions as clearly in the empirical study as in the academic literature. Fourth, the interviews have shown that value creation in the physical store is highly dependent on personal perceptions. However, this variability based on individual profiles as well as the many references made to the necessity of matching either expectations or personality tend to confirm and complement previous conclusions. Based on this insight, value of the in-store experience can thus be visualized as:

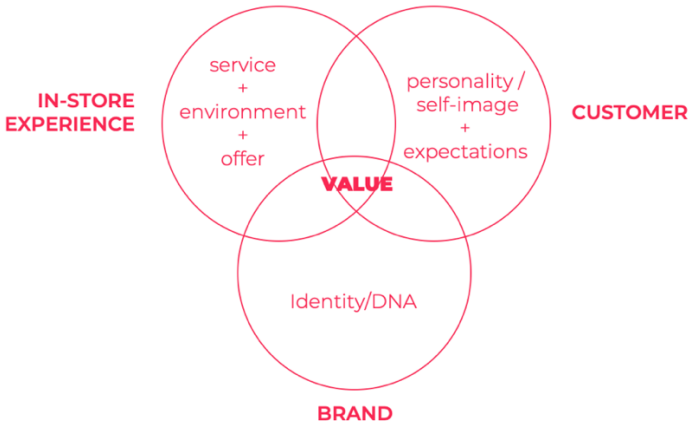

Figure 2. Visualization of the value of in-store experience

Lastly, the study has highlighted that although value is individually perceived, customers still seem to focus on the 'traditional' elements of the store before looking for an additional facet to their experience. This would point to the need for the operational aspect of the store to be considered first before adding its experiential dimension. The exact balance between the two as well as the level or type of experience is however customer and also brand dependent.

6 Contributions, limitations and future research

This research contributes to existing knowledge in three ways. First, it aids in grasping a more holistic and comprehensive overview on the value of experiential retail environments and more particularly so as this relates to the considerations of practicing retail designers. To date, the two notions of 'value' and 'in-store experience' have been widely researched separately and almost never with a view to apply it to design practice specifically. Secondly, this article contributes to the academic literature by adding to the still rather limited retail design theory base and also starts to create more links between this field and that of marketing. Third, it contributes to practice by highlighting not only gaps between stakeholder perspectives but also issues in the current ways of working and provides initial insight on how to potentially address these.

A number of limitations to this study can be found. First, the study was conducted using a specific context: five mid-level fashion brand stores in Antwerp, Belgium. To generalize results, similar studies should be conducted in additional and more varied locations as well as on different store categories. Secondly, for practical reasons, the number of respondents for each stakeholder group had to be limited to a manageable amount. As a result, further research would be required to strengthen results within each group as well as in-between groups.

Additionally to the above two proposals for further investigation, we would also propose the following research agenda:

- More in-depth research on terminologies, as the empirical study has only partially clarified the terms 'experiential store' and 'value'.
- Retail design specific research and particularly as regards the value construct since it is apparent that it is a key concern for all stakeholders but that much uncertainty and differences in perspectives still exist.
- Further research regarding the retail design process and how both experience integration and value creation fit into it.

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